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THE CONSERVATIVE TREATMENT IN SURGICAL TUBERCULOSIS OF THE LOWER EXTREMITY*

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INTRODUCTION

In the first place, I beg to thank the American Orthopaedic Association for the honor in asking me to take part in the sessions of your Congress by discussing the treatment of bone and joint tuberculosis of the lower extremities. I would have accepted with alacrity the friendly invitation of your Chairman and the alluring prospect of a pleasant journey to Boston, and I was still further tempted by the honor of this call, by the choice of a subject which interests me in the highest degree, and by the privilege of discussing it with so many persons who are particularly skilled in the subject of Orthopaedic Surgery, as well as by the pleasure of finding among you many old and trusted friends. Unhappily, I am prevented from carrying out this pleasant project by the necessity of presiding on June 9 at the inauguration of the International Factory Clinic in Leysin. In expressing my regrets to you, I offer you my repeated thanks and my best wishes for the complete success of your Congress and for the prosperity of your distinguished Association.

Your Chairman of the Program Committee, with his kindly courtesy, has expressed the desire that my unavoidable absence should not prevent me from submitting a short account of the conservative treatment of tuberculosis in the lower extremity, representing especially the progress of some cases in which the successful treatment was achieved a considerable time ago. I shall abstain from any unnecessary digression, and shall let my pictures speak in the language of facts. My only regret is that the limited time obliges me to restrict their number, and will prevent my saying more about them.

* Prepared by invitation for the Annual Meeting of the American Orthopaedic Association, Lakeville, Massachusetts, June 19, 1930.

At Dr. Wilson's request, I searched for the cases I treated when I first started my work at Leysin; which will explain why a few cases have no x-ray photographs, for at that time the equipment was not complete and the first x-rays are not quite clear as the art was then in its infancy.

During the four years in which I had the great privilege of being assistant to Prof. Kocher at Berne, the contact with this great surgeon fired me with an enthusiasm for surgery. From that time this enthusiasm has increased more and more, while at the same time there has been an increase of my admiration for the immense progress that this great art has realized in all its branches, with one solitary exception,—that is in regard to surgical tuberculosis. Although I have ceased to follow the development of surgery in this field, I do not think that I have mistaken the teaching of my respected master whose precepts have guided me like a beacon, and who often repeated to me these words which have remained deeply graven in my memory: "The greatest surgeon is he who is able to refrain from operating".

My application to the study of the pathogenesis of tuberculosis led me to the conviction that the bacillus of Koch was among all infectious maladies the one in which the biological conception of the "soil" played the most important rôle. Accordingly I set myself to oppose the commonly received but erroneous conception that external tuberculosis, called improperly "surgical" tuberculosis (because it was the *apanage* of the surgeon), was a disease in itself, a simple local illness, susceptible of being cured by local treatment or, like a tumor, of being extirpated with the knife.

If the bacillus was one factor of the problem, the "soil" was another, and one of much more importance, considering that one could regard the development of an external tuberculosis as dependent above everything upon the weaknesses or the resistances of the organism attacked.

Throughout the twenty-seven years of my career in heliotherapy, I have never ceased to urge that the local manifestations of that form of tuberculosis called "surgical" are but the manifestations of a general disease, the secondary evidences of the bacillary infection, whose destructive rôle can only be exerted as the result of want of psychophysical equilibrium in the individual. If then the problem is presented under a double aspect, its rational treatment demands a double activity.

To a general malady presenting local foci, one must in the first place oppose a general therapy, which will consist in stimulating the enfeebled resistance of the organism, in reconstituting the "soil", by intensifying every vital activity which can restore the broken equilibrium both in the province of physique and in the province of morale, from which the former is inseparable.

To this general treatment one will add local treatment, which, in order to be rational, must not only present no obstacle to the general defense of the organism, but must further make an effective contribution to the local defense. Such a combined attack will have the effect of forcing the attacking microbe to abandon its position.

To realize this double therapeutic purpose, I have, since 1903, recommended heliotherapy for surgical tuberculosis; that is to say,—not the *local* heliotherapy, which had been practised before me by Bonnet and Poncet at the school of Lyons, and later by Bernard in the Engadine, but *general* heliotherapy, applied to the whole body, and having the effect of replacing it in full contact with the two regenerators of life, the air and the sunshine. At that time I was a surgeon in Leysin, situated at a height of 4500 feet, where the air employed was the tonic, life-giving air of the mountains, and the sunshine consisted of rays intensified by altitude. These were the agents which were to benefit my cases of "surgical tuberculosis"; for these I renounced from that time the appeal to the knife, of which I had come to recognize the uselessness and the danger. Experience did not take long to demonstrate how rational was this sun-air-Alpine treatment, because it revealed itself as the most powerful possible stimulant of the metamorphoses and of vitality in the organism, and thus formed the best restorative agent for the "soil". At the same time it was found to be an ideal local treatment on account of the analgesic, resolvent, hardening, and recalcifying action of the solar rays.

In recommending general heliotherapy, I insist that the rational exposure to light is furnished to us by the *complete* solar spectrum; for I consider that the latter is inseparable in its nature, and that its rays of all wave lengths are indispensable for its harmony of action. It cannot be too frequently repeated that the *entire* spectrum must be applied to the *entire* area of the skin. One of the reasons that led me to recommend complete insolation was my conviction, which has grown constantly stronger, that the skin plays a rôle of capital importance in the general economy. The skin is not only an organ of protection, but is also an organ essential to the circulation, which it regulates, acting as a veritable peripheral heart. It is also an organ of innervation, like a most sensitive keyboard upon which all the radiations play with most delicate fingering, and from which vibrations, transmitted to the nerve centers, call forth their resonances of beneficial character that penetrate to the remotest parts of the organism. It is also an organ of secretion and elimination. Finally, it is an organ essential to immunization, and one of internal secretion intimately associated with the endocrine glands, and capable of supplying in part deficiencies of the latter.

If, therefore, I recommend general heliotherapy of the integuments, it is because this *alone* is capable of regenerating them, and allowing their numerous functions to play their essential parts, so as to set up a most admirable defensive system for the organism. Heliotherapy exercises a definite restorative influence upon the muscular system, and the restoration of the latter is no less important than that of the skin in the defense of the organism against tuberculosis. Progressive regeneration of the muscles aids the general circulation. General heliotherapy, in restoring to them their original tonicity and firmness, reestablishes and strengthens the action of these natural levers, and aids the return of the functions of the joints in an eminently physiological manner.

FIG. 1-A
Hip joint disease with infection. Complete destruction of the epiphysis. Active focus in the acetabulum.

FIG. 1-B
Hip joint disease (left). Condition extremely severe with infection. Faulty position. Multiple sinuses. Cachexia.

FIG. 1-C
Clinical state twenty-one months later. Cure complete. Good general health. Partial return of articular function.

FIG. 1-D
Cure. Good demarcation and structure.

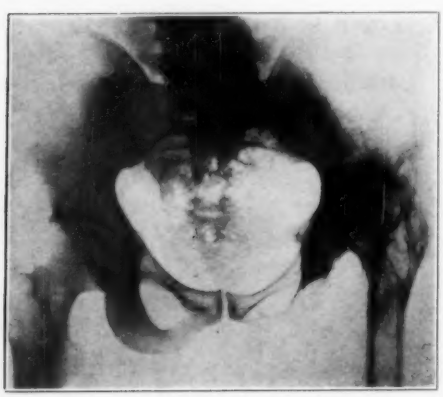

FIG. 1-E
Fifteen years later. Cure maintained. Consolidated structure.

FIG. 1-F
Clinical state fifteen years later. Recovery maintained.

We can only mention here the restorative action of the sun's rays upon the blood and upon the general metabolism and the metabolism of salts. In regard to osteo-articular tuberculosis, the most striking action of such a general heliotherapy as we have advocated is shown by its influence upon the bones. Mineral metabolism is so favorably modified by the action of the sun's rays that the amount of calcium and phosphates in the blood rises, not only to normal but even passes the acid-basic equilibrium, contributing thus to the recalcification which is clearly shown by radiographs of the focal-perifocal regions that have been decalcified by the hyperacidity which the bacillary process provokes. This recalcifying property, which I noticed at the very beginning of my practice, not only as regards bone and joint tuberculosis but also in rickets, has been confirmed and restated, as you know, by the remarkable researches of Hess and his pupils in your country, and by those of Huedchinsky in Germany as regards the action of ultra-violet rays. I have at my disposal a collection of more than 60,000 radiographic negatives, in which one can follow in all its details the action exerted by general heliotherapy upon every bacillary localization of osteitis and osteo-arthritis, and even demonstrate the recalcifying, cicatrizing, and restoring influence. However, in order that heliotherapy may exercise its maximum effectiveness, it is necessary that it should be practised according to certain principles of dosage and of exact technique. These rules, established from the beginning of my heliotherapeutic practice, and rendered more precise in proportion as my experience progressed, are absolutely essential. They form the very basis of treatment, and if one does not observe them, the sick person and the physician are exposed to certain disappointment.

The practice of heliotherapy, which has proved so admirably conservative and restorative, led me quite naturally to abandon operative interference in all closed cases of bone and joint tuberculosis. During twenty-seven years, I have never been required to have recourse to a single resection of the hip, and never to an arthrodesis. Very rarely—actually in three cases only—have I had recourse to resection of the knee in an adult, but never in the case of a child. Throughout all this time, I have performed *not one* resection of the tibiotarsal joint, nor even an excision of the astragalus. I have only occasionally resorted to sequestrectomy, and then only when the sequestra were necrosed through secondary infection. In closed osteitis and osteo-arthritis the sequestra *always* are reabsorbed and organized. An operation, which wounds and too often mutilates, enfeebles the defense of the local tissues, and often even the general defensive power. It produces a "*locus minoris resistentiae*" which aids the bacterial infection to attempt a recurrence. Finally, it risks opening the door to secondary infection which is infinitely more serious than the tuberculosis itself, and which too often sooner or later signs the death warrant of the patient.

Heliotherapy led me also to banish rigidly the closed plaster apparatus, which forms the greatest physiological and orthopaedic mistake of our times. Such an apparatus atrophies the skin and annihilates its many vital functions, which are indispensable for the defense of the organism;

FIG. 2-A

FIG. 2-B

FIG. 2-C

FIG. 2-D

FIG. 2-E

FIG. 2-A. Left hip joint disease. Patient suffering at the same time from dorsal Pott's disease. Considerable atrophy of the head; disappearance of the articular space. Structure hazy.

FIG. 2-B. Cure of the hip disease and Pott's disease after two years. Reappearance of the articular space (normal width); good trabecular structure (thick network).

FIG. 2-C. Clinical condition two years after arrival at Leysin; cure of hip disease; return of articular function. Restoration of the muscles. Good general health.

FIG. 2-D. Eight years after departure from Leysin. Cure well maintained and consolidated. The trabecular structure more accentuated.

FIG. 2-E. The same patient eight years after departure. Cure of hip and Pott's disease well maintained; further increase of articular function. Sportswoman.

RESULTS OF TREATMENT OF TUBERCULOSIS OF THE LOWER EXTREMITY

TUBERCULOSIS OF THE HIP JOINT.

Immediate Clinical and Radiological Results Obtained with the Sun Cure.

Cured:	Improved:	Stationary:	Deceased:
70.7%	20.9%	4.6%	3.8%

	Cure with return of articular function	64.0%
	Cure with normal return of articular function	40.6%
	Cure with partial return of articular function	61.0%
	Ankylosis	34.0%
End Results:		
	Cure maintained with function	74.0%
	Cure maintained with (*a*) normal function	33.6%
	Cure maintained with (*b*) partial function	66.4%
	Ankylosis	26.0%

TUBERCULOSIS OF THE KNEE JOINT.

Immediate Clinical and Radiological Results Obtained with the Sun Cure.

Cured:	Improved:	Stationary:	Deceased:
71.9%	24%	2.5%	2.1%

	Cure with return of articular function	66.8%
	Cure with normal return of articular function	58.4%
	Cure with reduced articular function	41.5%
	Ankylosis	33.2%
End Results:		
	Cure maintained with function	66.4%
	Cure maintained with (*a*) normal function	41.9%
	Cure maintained with (*b*) partial function	58.1%
	Ankylosis	33.6%

TUBERCULOSIS OF THE FOOT.

Immediate Clinical and Radiological Results Obtained with the Sun Cure.

Cured:	Improved:	Stationary:	Deceased:
78.5%	14.2%	3.5%	3.5%

	Cure with return of articular function	81.8%
	Cure with normal return of articular function	66.6%
	Cure with partial return of articular function	33.3%
	Ankylosis	18.1%
End Results:		
	Cure maintained with function	92.6%
	Cure maintained with (*a*) normal function	67.0%
	Cure maintained with (*b*) partial function	25.0%
	Ankylosis	7.2%

it also atrophies the muscles which are as necessary for the circulation as for the normal play of the joints. These rigid shells, which lead to absolute immobility and the complete exclusion of light from the affected joint, produce in their turn an obvious decalcification, which aids the bacillary osteitis to produce still further destructive processes. The plaster apparatus, when worn for a long time, may have results that are irremediable from a functional and social point of view, and it will be by no means one of the least claims to fame enjoyed by heliotherapy that it has shaken this dogma, which is too often regarded as unassailable, and which defies the simplest commonsense.

The practice of heliotherapy led me to adopt a more rational orthopaedic practice, based upon the same principles as the sun cure, with the object of securing the local defense of the region concerned, while safeguarding the soundness of its skin and muscles, as well as the vital action of the circulation in the joint as a whole. Although my mode of treatment may include rigorous maintenance of the horizontal decubitus, it does not

FIG. 3-A

Severe hip joint disease. Extended focus of the head and neck; sequestrum present; focus in the acetabulum; luxation at the onset.

FIG. 3-B

Advanced tuberculosis of the hip joint. Faulty position. External rotation. Marked lordosis and shortening.

FIG. 3-C

Eighteen months later. Correction of the faulty position. Restoration of the muscles.

FIG. 3-D

The same. Partial return of function.

FIG. 3-E

Eighteen months later. Cured; good demarcation of the acetabulum. Solid structure.

FIG. 3-F

FIG. 3-F Twenty years later. Cure maintained. Function maintained. Walks easily. Wears an orthopaedic shoe.

FIG. 4-A

FIG. 4-A. Condition on arrival; marked tumefaction of the knee due mostly to the fungi of the articular capsule.

FIG. 4-B. Severe osteo-arthritis of the knee. Perforation of a tibial focus into the joint. Voluminous fungi, sequestrum.

FIG. 4-C. Condition after one year and a half. Good sclerosis of the foci and building up again of the articular surface.

FIG. 4-D. Four years later; cure well maintained. Complete reorganization of the joint. Reappearance of trabecular structure.

FIG. 4-E and FIG. 4-F. Four years later; good function.

FIG. 4-B

FIG. 4-C

FIG. 4-D

FIG. 4-E

FIG. 4-F

FIG. 5-A

Gonitis sinistra. Epi-diaphysis focus. Puffiness of joint.

FIG. 5-B

Two years later. Cicatrization of the focus. Normal joint.

FIG. 5-C

Fifteen years later. Perfectly cured.

FIG. 5-D.

FIG. 5-E

Condition fifteen years later. Perfect general health. Cure of the gonitis. Remarkable articular function. FIG. 5-D. Leg in extension. FIG. 5-E. Knee in flexion.

FIG. 6-A

Osteo-arthritis of the right knee. Focus of the external epiphysis of femur extended to the level of the tibia.

FIG. 6-B

Eighteen months later. Joint free, bony focus cured. Good calcification.

FIG. 6-C

Eight years after cure: normal structure. Perfect state of joint.

FIG. 6-D

FIG. 6-E

Condition eight years after departure from Leysin. Good general and local condition. Articular function maintained.

involve a complete immobilization of the affected joint. My method of extension allows of a very cautious and very gradual separation of the joint surfaces, and of avoiding compressive, painful ulceration. This relative immobility permits, however, the small spontaneous movements of the joint, which always help the deep circulation, and along with this leads to healing of the bone foci as well as regeneration of the cartilages. (One knows that the vitality of the latter is maintained by exercise of the joint,

FIG. 7-A

FIG. 7-A. Condition on arrival. Osteo-arthritis of the foot; infected after three operations. Osteo-arthritis of left elbow. Bad general condition.

FIG. 7-B. Tibiotarsal arthritis; very extended and infected. Voluminous fungi.

FIG. 7-B

FIG. 7-C

FIG. 7-D

FIG. 7-E

FIG. 7-C. Eighteen to twenty months later. Cure. Disappearance of tibiotarsal joint. Nearthrosis constituted by the superior joints of the tarsus.

FIG. 7-D. Seventeen years later. Structure better consolidated.

FIG. 7-E. Condition on departure. Complete cure. Good general health; splendid musculature. Return of function.

FIG. 7-F. Seventeen years later. Well maintained cure. Very satisfactory return of articular function.

FIG. 7-F

FIG. 8-A

Talonavicular arthritis. Formation of sequestrum involving almost the whole scaphoid.

FIG. 8-B

Twenty months later. Demarcation between the astragalus and the cuneiform. One sequestrum still visible. Cure.

FIG. 8-C

Thirteen years later. Cure maintained.

FIG. 8-D

Condition thirteen years later. Cure well maintained. Married, at the head of an institute. Fearless sportswoman.

and that absolute immobilization leads irrevocably to their fibroid degeneration). The restoration of the cartilages, which is shown so clearly by reappearance of the joint space in my radiographs taken during treatment,

FIG. 9-A

FIG. 9-B

FIG. 9-C

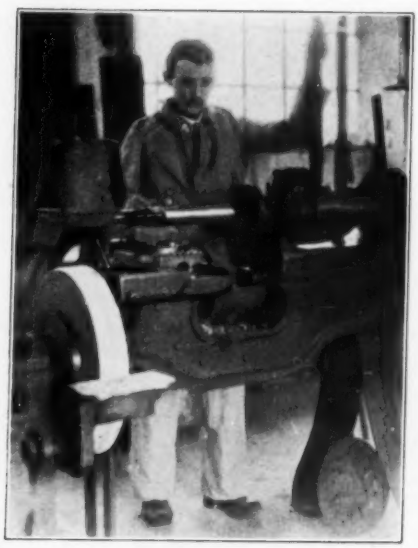

FIG. 9-D

FIG. 9-E

FIG. 9-A. Tibiotarsal osteo-arthritis. Mixed infection. Atrophy, large periarticular infiltration.

FIG. 9-B. Twenty months later. Joint freed again. Disappearance of fungus. Good structure.

FIG. 9-C. Thirteen years later. Perfect sclerosis.

FIG. 9-D and FIG. 9-E. Clinical condition thirteen years later. Cure maintained. Partial return of articular function. Married, father of four children. Mechanician in town, sportsman.

is responsible in large measure for the frequency with which functional movement is recovered.

Heliotherapy, by the strikingly decongestive effect that it exerts upon the diseased part, produces a feeling of relief and freedom from pain that contributes greatly to raising the morale of the patients.

From the clinical point of view, the combined action of heliotherapy and of this rational orthopaedic treatment shows itself in the diminution and disappearance of infiltrations around the joints caused by tuberculous oedema, and by the spontaneous absorption of cold abscesses. (I regard the cold abscess as a part of the healing process, a depot of antibodies, which contribute to immunization, and I therefore have recourse to puncture only when the abscess has played its part and the organism is seeking to get rid of it.) This combined action also shows itself by a healthier state of the skin, development of the muscles and the more or less complete return of the function of the joints.

From the radiographic point of view, the cure is shown by the following five cardinal symptoms:

(1) Demarcation of a zone of sclerosis between the healthy tissues and the diseased tissues.

(2) Absorption of abscesses, infiltrations, fungosities, etc.

(3) Reconstruction in the zone of atrophy and softening of a new bony substance with strong trabecular meshwork.

(4) Reorganization of sequestra, filling up of cavities and of defects by connective tissue.

(5) Readaptation to functional demands by new joint formation.

There are certain distinctive radiological signs in connection with the three joints of the lower limb, and with the action that heliotherapy exerts upon them.

Hip Joint.

The synovial form of disease in this joint is rare, and is almost always the result of an unrecognized subchondral focus. Foci outside the joint are uncommon, and their prognosis is favorable like that of synovitis.

Foci in the neck of the femur, its head, and in the acetabulum are the general rule. Even when they are accompanied or followed by penetration into the joint and an extensive destruction, regular healing proceeds almost always without ankylosis. New joint formation, sometimes a little deformed, may modify the articular mechanism with resulting alteration of the ligaments and scars in the capsule, but these have nevertheless a good functional prognosis, and they show *less* tendency to recurrence than does ankylosis!

Knee.

The foci, both in the adult and in the child, have a more marked tendency to recovery than the synovial forms in which recovery is slower. In the healing of the knee, there is seen especially a formation of thick trabeculae, a sign of intense recalcification. The return of function is fre-

quently found, in spite of irregularities that may persist on the surface of the joint, although this return is less than in the case of the hip. In children, foci in the epiphyses are especially favorable.

Foot.

The tibiotarsal joint is, above all, most favorably influenced by heliotherapy. Even in cases where the destruction is far advanced, ankylosis is an exceptional result. The astragalonavicular joint shows remarkable powers of regeneration, even when sequestra are present. The same remark applies when the disease is localized in the os calcis.

It should be mentioned in passing that I attach great importance to the diet of patients, the diet being adapted to heliotherapy. A rational diet ought to be composed above all of those articles,—such as cereals, vegetables and fruit—which are rich in vitamins and in remineralizing substances, and which are comparable to the action of the sun. They are the irradiated foods *par excellence.*

To this program of a physical character (aero-heliotherapy, orthopaedics, and rational diet), it is indispensable to unite another factor, the morale. In any individual the morale and the physique are inseparable, and the harmony of their balance is really the condition of his health and of his happiness. The surgical tuberculous patient is often sick in spirit as well as in body, and irradiation of his inner being is just as necessary as that of the exterior. This is the constant aim of psychotherapy. This is also the object of the work cure that I have associated with heliotherapy, which has been established in its turn as a therapeutic factor of three-fold value,—mental, physical, and economic. I have endeavored to raise this into a system of treatment by the creation of the International Factory Clinic, the inauguration of which has prevented me from being with you to-day. It is destined for patients of both sexes affected by surgical tuberculosis and possessing small means; without regard to nationality, it puts at their disposal, along with a modern heliotherapeutic establishment, an organization of industrial work which allows them to earn the means for their subsistence and treatment, while at the same time preparing themselves for the return to their life of normal activity. In this way the very complex problem of the cure and of the future for surgical tuberculous cases will be solved in a very rational manner. By the realization of this project, a new step will have been taken in the field of the fight against tuberculosis, and also in the line of progress, because in the very course of events, the poor affected by surgical tuberculosis will be elevated to the position of the privileged.

I shall be happy, gentlemen, if this humanitarian and medicosocial work, so full of promise, but so burdened also by responsibility, shall find in your minds and hearts the interest and the sympathy of which it stands so much in need.

THE TREATMENT OF TUBERCULOSIS OF THE JOINTS OF THE LOWER EXTREMITIES BY OPERATIVE FUSION*

BY RUSSELL A. HIBBS, M.D., NEW YORK, N. Y.

In estimating the results of the treatment of tuberculosis of the joints of the lower extremities we have too often considered the disease cured or arrested in patients who were living comparatively normal lives, free from the symptoms of pain and disability which we ordinarily associate with active disease. We have failed to realize that in many instances freedom from such symptoms and the excellent condition of the general health, with relatively normal activity, are not trustworthy evidence of arrested or cured disease. This is particularly true of cases in which the disease begins in childhood, as it most frequently does. It is not unusual to see such cases continue for periods of from five to ten years without the appearance of any of those acute attacks of pain and disability, with abscess formation, etc., which constitute conspicuous evidence of active disease. We see patients in our clinic, and, of course, they are seen in other clinics, who have had active tuberculosis of a joint for thirty or forty years. To be sure, such cases are few in number because serious disability occurs in most instances much earlier and often with a fatal termination.

End-result studies in the past, based upon five or even ten years' observation, have led to many errors in estimating cases as cured or arrested when a longer and more careful follow-up study would have shown that the disease was not arrested or cured, but had been constantly and slowly progressing. Two studies were made in our own clinic. The first, fifty-one cases of hip-joint tuberculosis, was made by Shaffer in 1887 and published in the *New York Medical Journal* of May 21, of that year. The observation of these cases was for an average period of six and one-half years. The second was made by Humphries and Durham and published in the *Journal of the American Medical Association* January 27, 1917. In this instance 461 cases of hip-joint tuberculosis, 165 cases of knee-joint tuberculosis, and 50 cases of ankle-joint tuberculosis were studied for an average period of about seven years. Both groups of patients had been treated mainly in the out-patient clinic, with occasional short periods of hospitalization.

The value of these reports is vitiated by two faults, which, I venture to suggest, are common to most reports of the same period on this subject. First, the methods of diagnosis were inaccurate; second, the period of observation was too short to give complete knowledge of the course of the disease in the individual case. These reports were based, as have been many oth-

*Read at the Forty-fourth Annual Meeting of the American Orthopaedic Association, Lakeville, Massachusetts, June 19, 1930.

ers, very largely upon the study of cases under treatment in the out-patient clinic. While the number of cases may have been many, it is doubtful if, generally speaking, we may expect patients suffering from a disease which lasts so long to make their visits to the clinic frequent enough. It is necessary that they do so, however, if we are to have a complete knowledge of the course of the disease in the individual patient, or of the influence upon its course of any special method of treatment.

These difficulties led the New York Orthopaedic Hospital to establish in 1904 a branch in the country for the treatment of joint tuberculosis where patients could be taken and kept for an indefinite time in the best possible surroundings, where every influence of good air, sunshine (heliotherapy), and the constant application of the so called conservative methods of treatment which had been considered effective could be insured. Upon their discharge they returned to the out-patient clinic in the city for further observation, their frequent attendance being procured by the aid of a corps of visiting nurses.

We entered upon this work with the confident belief that these children would get well, with good, safe, mobile joints, in a comparatively short time. However, an estimate of results in these cases made upon their discharge after residence in this hospital of from four to seven years, was as misleading as to the cure or arrest of disease as had been so many reports in the past. Although such a study was prepared in 1916, it was, fortunately, not published. The patients were sent home to resume the normal life suitable to their age and to be kept under constant observation for a longer period.

At intervals varying from one to ten years after discharge from the country branch many of the patients began to show unmistakable signs of active disease. Often they were those who apparently had had the best results. Many of them have come to operation and we expect others will come. This operative experience gave an opportunity to obtain accurate knowledge of the condition of these joints. In none had cure been effected, nor was the disease quiescent in any. In many instances, through the years of illness, such a protective skill had been developed in the use of the diseased joint, even when engaged in occupation requiring laborious activity, that a false sense of security was given to both the patient and the surgeon. Neither one could believe that an active tuberculosis was present. It often requires the most careful search into the history of the patient, as well as a painstaking examination of the joint, to find those slight but significant symptoms of activity in the progress of this insidious disease. These symptoms may be slight pain on use of the joint after rest, especially upon getting up in the morning, fatigue after activity, the presence of muscle spasm.

An end-result study, covering a period of fifteen years in each instance, of 208 patients with hip-joint tuberculosis, who had resided at the country branch from four to seven years, was made by Smith and Watters and published in the *Journal of the American Medical Association* of January 21, 1928. In twenty-two per cent. of these cases incorrect diagnosis had been

made; twenty-four per cent. had died, mostly from other forms of tuberculosis; in forty-seven per cent. the disease was unmistakably active; in twenty-seven per cent. there was apparently quiescent disease, with little or no motion and some degree of deformity. Only two patients were free from symptoms and had a useful range of motion.

Another study was made from this series of seventy-seven cases of knee-joint tuberculosis by Hibbs and von Lackum, which was published in the *Journal of the American Medical Association* of October 24, 1925. In ten

FIG. 1

A. S., aged 6, history 60963. Hip-joint tuberculosis proved by exploratory operation. Fusion April 11, 1923. Follow-up after six years.

of these cases a mistaken diagnosis was made; seven died, mostly from other forms of tuberculosis; thirteen never became quiescent; sixteen relapsed and have been fused and are well; twenty-six cases were still apparently quiescent at the date of this study, limping about with varying degrees of mobility and deformity; three cases had bony ankylosis and two fibrous ankylosis.

> "The average age of onset was four years. The duration of time before the quiescent period was reached was, on an average, six and one-half years. The average age at which relapse has occurred in quiescent cases was seventeen years, seven years after discharge. The relapses to date among the cases that became quiescent are well over one-third of the series. The average period during which these patients have been observed is something over fifteen years, the longest twenty-four and the shortest six years."

The results of the treatment of patients with disease of the ankle joint are essentially similar.

FIG. 2

H. H., aged 13, history 19566. Knee-joint tuberculosis proved. Fused February 3, 1920. Follow-up after ten years.

In the light of the facts obtained from these studies we began to doubt the efficacy of these methods of treatment and to wonder whether or not these joints ever get well, with mobility, a result which we had so persistently striven to obtain, at so great an expense to the hospital and at such a sacrifice to the developing lives of these growing children by long hospitalization. Is it surprising that we began to consider the elimination of motion in these joints by operative fusion as the only means available for their cure?

It cannot be stated that no case of tuberculosis of a joint of the lower extremity treated by conservative methods has been cured, with mobility. It is fair, however, to say that it is a rare occurrence, and that it is unsafe to claim a cure unless the diagnosis has been established by methods which are more reliable than those which have generally been used in the past and which are still being used in some clinics to-day. The only trustworthy methods we now have are laboratory methods which require the removal of tissue from the joint, necessitating an exploratory operation,

FIG. 3

M. E., aged 13, history 36304. Ankle-joint tuberculosis proved. Fused April 19, 1923. Follow-up after seven years.

except when the diagnosis is made possible by the aspiration of pus. Without proved diagnosis how can one reach a true estimate of the value of any method of treatment, whether it be called conservative or radical?

We began to fuse the knee joint in January 1915, and in the period of twelve years to January 1926 we had obtained fusion in 154 knee joints with proved tuberculosis. In April 1923 we fused by operation, for the first time, a case of hip-joint tuberculosis, and in the period to December 1928 we had operated upon 150 cases, securing fusion in 139 or ninety-two per cent., with failure in eleven cases or eight per cent. Operative fusion of the ankle and tarsal joints was begun in April 1923. Up to September 1927 eighteen cases of proved ankle-joint tuberculosis and four cases of tarsal tuberculosis had been done. In all these cases fusion was obtained.

In no instance has there been a recurrence of disease in any of these fused joints, and the limitation of the patients' activity which might have been expected has not been experienced. On the contrary, they all engage in most activities with greater freedom, no pain, less fatigue, and more confidence than before fusion had taken place. This is especially true of children, and particularly of the hip, the ankle, and the tarsal cases. Because of the compensation which takes place in the lumbar spine after hip fusion, in the tarsal joints after ankle fusion, and in the free joints of the foot after tarsal fusion, the patients are almost entirely free from any handicap in ordinary activity. In the knee cases the chief disadvantage is experienced in sitting.

Of still greater importance is the fact that these patients have been freed from the constant danger to life by extension of the disease from the active focus in the joint, as well as from the necessity of years of treatment in hospital or clinic.

THE NON-OPERATIVE TREATMENT OF TUBERCULOUS JOINTS OF THE LOWER EXTREMITIES*

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At first glance it may appear that those who claim that the treatment of non-pulmonary tuberculosis is a medical problem are diametrically opposed to those who feel that it is a surgical one. Actually we are not so far apart as it may seem. We certainly must agree that the entire elimination of surgery in dealing with joint tuberculosis would be as unwise as the omission of medical care of patients under surgical treatment. Where we do disagree, however, is as to the relative importance of surgery and conservative treatment.

In any discussion of the conservative treatment by heliotherapy in joint and, in fact, in any form of tuberculosis, it is important to consider the nature of the disease and the fundamental reaction produced by the treatment.

A patient with a tuberculous lesion is too often treated by the surgeon as though the only lesion to be considered were the local manifest infection. Often very little if any consideration is given to the fact that tuberculosis is almost invariably a systemic infection regardless of the particular local manifestation or expression which is apparent. How often is a patient, presenting himself with a tuberculous lesion, examined for other manifestations of the disease unless such manifestations are so apparent that one cannot very well overlook them? This indifference is not limited to the surgeon but is common to all of us who specialize.

At the J. N. Adam Memorial Hospital we have found over a period of years that sixty-five per cent. of the adult patients under treatment for all extrapulmonary lesions, show a definite though usually inactive pulmonary tuberculosis. Undoubtedly many more than this sixty-five per cent. have some pulmonary or other tuberculous involvement not detectable by physical signs or x-rays which would nevertheless show up on autopsy. This is not merely our own experience, but that of all who are engaged in tuberculosis work.

If this is the case, it is reasonable to expect that any merely local treatment of a tuberculous lesion, beneficial as it may be to that local lesion, may fail entirely to treat successfully the disease itself.

From the very nature of the infection with the tubercle bacillus, it is to be expected that progress, whether improvement or retrogression, is likely to be slow. So called short cuts often result in disaster. The organ-

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ism is slow growing and hard to destroy and we lack any specific therapy for dealing with it. Surgery, no matter how effective mechanically, may disseminate the disease and, besides, is likely to leave the patient who is already physically below par with a much lowered resistance toward infection. In view of this fact, frequent flare-ups in other parts, and even miliary tuberculosis following surgery, are not uncommon.

While we cannot deny that surgical interference may often be desirable, such procedure, we feel, should be reserved to deal with failures of conservative treatment and in complications,—such as a flail and painful joint—and to correct deformities; and, should be delayed until the patient's general condition has been well built up by a preliminary course of sun cure. Sometimes the patient's response to heliotherapy is so far beyond expectations that, following a preliminary course of heliotherapy, the contemplated operation is found to be unnecessary. To use the knife at a stage when the disease is active and when the patient's physical condition is poor, may cause irreparable harm.

The chronic character of tuberculosis permits a patient to build up a certain amount of specific resistance to the disease. That such a specific resistance can exist is shown by the very small number of active pulmonary lesions among patients with extrapulmonary tuberculosis, in spite of the frequency of pulmonary involvement in these patients. It is difficult to conceive how an extrapulmonary lesion can in any way favorably affect pulmonary tuberculosis except by conferring some immunity to the tubercle bacillus infection. In the treatment of pulmonary tuberculosis it is also common experience that the general condition of a patient will definitely improve even though for a time the local lesion increases in severity. It is likewise true that improvement in a so called surgical lesion follows and does not precede improvement in the general condition. It would seem logical then to take advantage of this specific immunity which a patient can build up in treating tuberculosis.

This would seem to call for conservative treatment with every effort directed toward improving the general condition of the patient and taking advantage of the defensive mechanism which nature has provided. If surgery must be resorted to, it should be undertaken, as explained above, after all activity has subsided and the patient has been brought up to his maximum physical improvement; and then only to correct deformities and for fusion in painful and flail joints, and in failures of conservative treatment. In other words, our efforts should be directed toward the treatment of the tuberculosis first, and deal with the local lesions as complications and as secondary to the general infection.

Essentially the aim in conservative treatment of a tuberculous joint with heliotherapy is twofold,—namely, the treatment of the tuberculosis as a systemic infection and, as an end result, the retention of some function of the joint. In contrast to this the aim in the surgical treatment is the fixation of the joint, on the ground that recurrence is much less likely in a joint in which all function is eliminated. The supposition is that the tuber-

culous joint is a disease entity and that, therefore, when the joint is apparently healed, the disease is cured. This last I feel is based on an erroneous conception of the character of the disease and I must emphasize again the fact that tuberculosis is fundamentally a systemic and a multiple lesion disease even though only one lesion may be apparent.

It may be contended that motion in a healed tuberculous joint is a liability, because of the greater likelihood of injury to such a joint. From our experience, I am not prepared to admit that this is true. But even admitting that a tuberculous joint healed with motion is somewhat more likely to break down than one healed with ankylosis, it is equally true that the surgery and anaesthesia involved in fusion, render the chances of metastasis to other joints and reactivation of the primary focus much greater.

Suppose that a tuberculous knee has been treated surgically and ankylosed. If a similar lesion develops in the other knee and is treated in the same way, the patient becomes almost helpless. With conservative treatment, not only is metastasis much less likely to occur, but if it does occur, the retention of complete or partial function in one or both joints gives the individual the advantage of the possibility of useful activity. This is not an extreme or unlikely case. We have in the Hospital at the present time two bilateral hip and two bilateral knee cases.

While the advocates of surgical treatment claim that no permanent cure can be expected in a tuberculous joint if ankylosis is not obtained, on the other hand the experience of Dr. Rollier and others who have used heliotherapy extensively does not bear out this contention. Besides, nothing is lost by instituting conservative treatment first with recourse to surgery if the conservative treatment fails. On the other hand, what is lost by attempt and failure of surgical treatment is sufficiently evident.

Since our treatment consists primarily in the employment of light therapy, it is important to consider very briefly what is known about the effects of the different portions of the optical spectrum. Ordinary sunlight, as it reaches the earth's surface at moderate altitudes, contains wave lengths ranging from as short as 2900 Angström units in the ultra-violet portion, through the visible spectrum, to 30,000 Angström units in the infra-red region.

From recent work in various quarters it appears that the maximum effect in both antirachitic action and pigment development in human skin occurs at about 2900 Angström units. The still shorter wave lengths artificially produced by the mercury and carbon arc possess the same properties, but their beneficial effects are limited by their marked irritant action. Proceeding to longer wave lengths, we find no other region in which a specific effect has been demonstrated until wave length 7600 Angström units at the red edge is reached. Here a specific thermal effect apparently occurs. This consists of an elevation of the capillary blood temperature, which, according to Sonne, appears to promote certain antibody formation and possibly other action in the blood stream.

At Perrysburg, we have failed to obtain with the ordinary type of artificial lights, clinical results comparable to those obtained with natural sunlight, although a considerable and representative number of so called therapeutic lamps have been tested by us both clinically and in the laboratory. This, of course, is in agreement with the bulk of reported work on the therapeutic use of sun and artificial light. This I have already pointed out in collaboration with Dr. Balderrey. Because of this, and keeping the foregoing in mind, Dr. O'Brien has developed artificial lights reproducing the total solar spectrum with a good approximation to the energy distribution throughout its full extent; and more recently, a lamp producing only the more important regions, outlined above, in high intensity and with high efficiency. These sources have been used to treat a large number of patients over the past several years with results which are more nearly like those obtained with natural sunlight than those we have obtained with any other form of artificial light. The more recent development, producing only what now appears the more important spectral regions, is proving particularly valuable because its relative simplicity and greater efficiency make it more generally applicable.

There have been discharged from the J. N. Adam Memorial Hospital up to January 1, 1930, 437 cases of bone and joint tuberculosis and seventy-two cases of osteomyelitis, non-tuberculous in nature, that remained in the institution three months or longer. Their condition on discharge was as follows:

Apparently recovered	235 or 53.8 per cent.
Arrested	101 or 23.1 per cent.
Improved	47 or 10.7 per cent.
Unimproved	34 or 7.8 per cent.
Dead	20 or 4.5 per cent.

Of the 437 cases of bone and joint tuberculosis:

108 or 24.7 per cent. were tuberculosis of the hip.
67 or 15.3 per cent. were tuberculosis of the knee.
42 or 9.6 per cent. were tuberculosis of the ankle.
9 or 2.07 per cent. were tuberculosis of the sacro-iliac joint.

Of the 108 cases of tuberculosis of the hip:

65 or 60.2 per cent. were discharged as apparently recovered.
21 or 19.4 per cent. were discharged as arrested.
13 or 12.0 per cent. were discharged as improved.
7 or 6.5 per cent. were discharged as unimproved.
2 or 1.8 per cent. were discharged as dead.

Of the 67 cases of tuberculosis of the knee:

35 or 52.2 per cent. were discharged as apparently recovered.
16 or 23.8 per cent. were discharged as arrested.
9 or 13.4 per cent. were discharged as improved.
4 or 5.9 per cent. were discharged as unimproved.
3 or 4.5 per cent. were discharged as dead.

Of the 42 cases of tuberculosis of the ankle:

29 or 69.0 per cent. were discharged as apparently recovered.
8 or 19.0 per cent. were discharged as arrested.
4 or 9.5 per cent. were discharged as improved.
1 or 2.4 per cent. were discharged as unimproved.

Of the 9 cases of sacro-iliac tuberculosis:

5 or 56.0 per cent. were discharged as apparently recovered.
2 or 22.0 per cent. were discharged as arrested.
1 or 11.0 per cent. were discharged as unimproved.
1 or 11.0 per cent. were discharged as dead.

No patient is discharged as recovered until he has been up and about for at least six months without any evidence of returning signs or symptoms. No patient is permitted to be up and about until x-rays show good repair, and all signs and symptoms have disappeared, ulcers and sinuses have healed, and abscesses absorbed or calcified.

A great number of patients, after they are up and about two or three months, become so restless that they leave the institution before the six months' probation period is up, and as a result the percentage discharged as apparent recoveries is reduced.

Twenty-four per cent. of the patients with joint tuberculosis who were discharged had multiple lesions on admission; forty-seven per cent. of the patients had sinuses complicating the lesion; and forty per cent., including children, had a clinically diagnosed pulmonary lesion.

While the immediate results of treatment are important, the success of such treatment rests with its end results. For this reason a survey of the first 500 cases of non-pulmonary tuberculosis discharged alive, and treated for over three months at the J. N. Adam Memorial Hospital, was completed in 1927. A total of 423 cases were actually surveyed. The rest were either dead or could not be located.

The status of these cases was determined as of January 1, 1927. The length of time since discharge from the hospital varied from less than one year to twelve years,—the average length of time since discharge six and seven-tenths years.

Of the total 149 cases of tuberculosis of the joints, 123 or eighty-two and six-tenths per cent. were of the lower extremities. Of these twelve or ten per cent. were entirely lost sight of, leaving 111 or ninety per cent. of the total number whose present status was obtainable. Thirteen or eleven and seven-tenths per cent. had died, of whom eight, or sixty-one and five-tenths per cent., died of tuberculosis (five from pulmonary and three from other forms of tuberculosis). Five of these or sixty-two and five-tenths per cent. had a clinically diagnosed pulmonary lesion and three did not present any pulmonary involvement during stay in hospital. Four of the former and one of the latter died of pulmonary tuberculosis.

FIG. 1-A

CASE 3024. Tuberculosis of left hip.

FIG. 1-A. X-ray on admission, showing abscess shadow extending through acetabulum into pelvis.

FIG. 1-B. X-ray three and one-half years later, showing calcification of abscess.

FIG. 1-C. Three and one-half years after admission.

FIG. 1-D. Three and one-half years after admission, showing motion. Patient able to walk without aid of crutch or cane. Gained twenty-one pounds. (No photograph taken on admission, patient unable to stand.)

FIG. 1-B

FIG. 1-C

FIG. 1-D

The average length of treatment in the cases by type of lesion was as follows:

Length of stay:	Lesion *Hip*	*Knee*	*Ankle*
3–6 months	7 or 9.6 per cent.	2 or 6.2 per cent.	3 or 16.6 per cent.
6–9 months	5 or 6.8 per cent.	4 or 12.5 per cent.	
9–12 months	1 or 1.4 per cent.	3 or 9.4 per cent.	4 or 22.2 per cent.
12–18 months	16 or 22.0 per cent.	10 or 31.2 per cent.	2 or 11.1 per cent.
18–24 months	14 or 19.0 per cent.	4 or 12.5 per cent.	1 or 5.5 per cent.
2–5 years	28 or 38.0 per cent.	8 or 25.0 per cent.	8 or 44.4 per cent.
5 years	2 or 2.8 per cent.	1 or 3.1 per cent.	
	73	32	18

One of the unique phases of the study was the large number of actual reexaminations which it was possible to have made. Of the cases with tuberculosis of the lower extremity, ninety-one or seventy-four per cent. of the cases with tuberculosis of hip, knee, or ankle were reexamined by a physician. These cases were rated according to the disability of the organ affected by the primary lesion. According to physician's report:

19 or 20.0 per cent. recovered completely.

18 or 19.1 per cent. had a slight disability.

20 or 22.0 per cent. were disabled to a considerable degree.

34 or 37.4 per cent. were completely disabled.

The definitions of the classifications used above are as follows:

Recovered completely	Complete recovery with no lameness, anylosis, or limitation of motion.
Slight disability (less than twenty-five per cent.)	Small limitation or ankylosis, with or without some continuance of infection.
Disabled to a considerable degree (twenty-five to seventy-five per cent.)	Considerable limitation, lameness, or continuance of infection to considerable degree.
Completely disabled (more than seventy-five per cent.)	Complete or nearly complete disability, loss of organ (amputation, etc.) or entire uselessness of organ.

To ascertain what restoration was made of the patient to his place in the economic world, a further inquiry was made into the working capacity of each living patient.

Eighty or eighty-seven per cent. were working, or in case of children, attending school.

Eight or ten per cent. were ambulant, but unable to work.

Five or three per cent. were bed cases.

The classification of functional capacity given is based on the following definition:

Working:	This includes patients normally working but unemployed at present, children in schools, and young children able to carry on normal play activities.
Not working—ambulant:	Unable to work, but not bedridden.
Not working—bed patients:	Unable to carry on any activity.

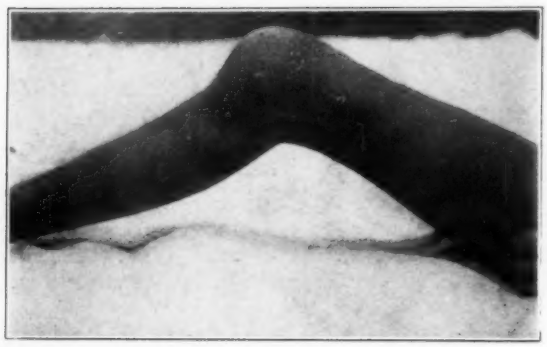

FIG. 2-A

FIG. 2-A. Local condition on admission.

FIG. 2-B. X-ray on admission.

FIG. 2-C. X-ray two years and three months later.

FIG. 2-D. On admission. June 1921.

FIG. 2-E. Two years and three months later.

FIG. 2-F. Two years and three months later, showing motion.

FIG. 2-B

FIG. 2-C

FIG. 2-D

FIG. 2-E

FIG. 2-F

CASE 3300. Tuberculosis of left knee with subluxation of joint and flexion deformity. Diagnosis confirmed by animal inoculation. At present, patient is in excellent condition with no evidence of recurrence.

FIG. 3-A

FIG. 3-B

FIG. 3-C

FIG. 3-D

FIG. 3-E

FIG. 3-A. Local condition on admission.

FIG. 3-B. Local condition two years later; range of motion only slightly limited.

FIG. 3-C. X-ray on admission.

FIG. 3-D. X-ray two years later.

FIG. 3-E. On admission.

FIG. 3-F. Two years later.

FIG. 3-F

CASE 2799. Tuberculosis of left ankle. Proved tuberculosis by pus from sinus.

The following is a summary giving comparative statistics according to lesion:

		Tuberculosis of		
	All joints	*Hip*	*Knee*	*Ankle*
Total cases	149	73 or 49.%	32 or 21.%	18 or 12.%
Total cases studied	133	67	30	14
Total cases examined	107	55	25	11
Sex				
Male	92	50 or 68.%	17 or 53.%	9 or 50.%
Female	57	23 or 32.%	15 or 47.%	9 or 50.%
Average years since discharge	6.7	6.6	6.4	6.7
Percentage of deaths in known cases	13.5	11.9	10.0	14.3
CAUSE OF DEATH: in cases with a diagnosable pulmonary lesion				
Total	9	3	2	1
Pulmonary tuberculosis	7	2	2	—
Other tuberculosis	1	1	—	—
Other causes	1	—	—	—
Accidents	—	—	—	—
CAUSE OF DEATH: in cases without a demonstrable pulmonary lesion				
Total	9	5	1	1
Pulmonary tuberculosis	2	1	—	—
Other tuberculosis	2	1	—	1
Other causes	4	3	1	—
Accidents	1	—	—	—
DISABILITY OF ORGAN affected				
Entirely recovered	23	12	3	4
Slight disability	23	6	8	4
Considerable disability	24	13	4	3
Complete disability	37	24	10	—
WORKING CAPACITY of individual				
Working	95	47	22	11
Ambulant	6	5	3	—
Bed cases	5	3	2	—
Unclassified	—	—	—	—

In summary, may I emphasize again:

1. That tuberculosis is a systemic, not a local disease, irrespective of the particular local manifestations which may be present.

2. That a patient with a tuberculous joint should be treated for the systemic infection and the joint treated as a complication, not as the primary infection.

3. That operative procedure is likely to disseminate the disease, especially if undertaken during the acute stage.

4. That if surgery must be resorted to, it should be done only after a preliminary course of conservative treatment so as to bring the resistance of the patient to a maximum.

5. That from the experience of both Dr. Rollier and ourselves, such conservative treatment usually results in healing with useful motion, and retention of that motion without recurrence of the disease.

In conclusion, let me repeat that my viewpoint is that of one treating tuberculosis and that only a small proportion of our cases have joint complications. Quite naturally, then, I see tuberculosis from a viewpoint different from that of the orthopaedic surgeon. This very fact, however, is perhaps justification for my presumption in presenting to you what would otherwise be an orthopaedic subject.

DISCUSSION

Dr. Edwin W. Ryerson, Chicago: As I understand it, this is an attempt to evaluate in some scientific way the relative value of the strictly conservative orthopaedic treatment of joint tuberculosis and the equally conservative but, to some people, more radical method of treatment by fixation of the joint. For a great many years I have been, as you all have been, dissatisfied with the results of the strictly conservative orthopaedic treatment. In the first place, the time required is indefinite. No one can tell when a tuberculous joint is well unless it becomes fused by the operation of the inflammatory conditions in that joint or by open operation. The most striking thing I can remember was possibly some twelve or fourteen years ago when a number of us were in Minneapolis at a clinic given by Dr. A. J. Gillette. It was so striking that although many of you have heard the statement before and some of you were there, I am going to repeat it. Dr. Gillette brought in eleven or twelve cases of unquestioned tuberculosis of the knee joint, all adults. The procedure was about as follows: "Here is Mrs. S. She is thirty-two years old. For the past twelve years she has been wearing a long plaster splint or leather apparatus reenforced with steel and she has gotten along beautifully. As long as she wears this splint she has no pain and she gets along perfectly well. If she leaves off the splint temporarily for a day or two she begins to have more pain in the knee."

"This next case is Mr. J. who has been for fourteen years under my care. He has the same history as the preceding case. If he takes off the apparatus he begins to have difficulty. When he puts it on again and immobilizes his knee he gets on perfectly."

And so on for at least a dozen cases. The good man exhibited them with pride. He was somewhat dismayed when he asked for discussion and I pointed out that not one of the dozen patients was one bit nearer well than on the first day the appliance was applied. These old knee joints have so much disease and so many live tubercle bacilli in the joint that ten or more years of as complete immobilization as can be obtained with a splint reaching from the perineum to the ankle does not cure them, so that I am convinced that adults with this type of tuberculosis do not get well without operation. Up to this time I have seen no proved case of knee joint or hip joint tuberculosis in any individual, young or old, get well without fusion by nature or fusion by operation on that joint. I have come to the conclusion that all cases that can be demonstrated to be tuberculous in either the knee or hip or spine should be fused by operation if there is no immediate prospect of fusion by natural processes. Phemister showed many years ago why that much-to-be-hoped-for consummation of this terrible condition cannot be accomplished.

Dr. Frederick C. Kidner, Detroit, Mich.: It is very difficult when one is entirely convinced of the wisdom of operative fusion of tuberculous joints, to comment on the

paper of an exponent of extreme conservatism. I think the men who are unwilling to undertake the operative fusion are still affected by the wail of the mother, "I cannot let my poor boy be a cripple". The idea of a stiff knee or hip to the laity is a dreadful thing. As a matter of fact, the child who has a stiff knee or hip adapts himself to it so thoroughly that he is usually better off than he would be if he had a few degrees of motion left after long years of conservative treatment.

The problem entirely aside from the patient's comfort and safety is an economic one. I have had at Farmington, near Detroit, for nearly fifteen years the best possible plant for the treatment of joint tuberculosis. In all that time we have had no satisfactory result in hip and knee disease treated by conservatism. In the spine we have done better and compared well with operative treatment. I have never yet seen a case which was cured with useful motion.

About the danger of operation, Dr. Lo Grasso said something that is very interesting. He said that hip disease or knee disease is a part of a general process. That is perfectly true, but to my mind the infected joint is a most important factor in keeping the general process going and in keeping the general condition of the patient poor. In other words, the sooner we can get rid of the joint infection by fusion, the sooner the child will get rid of his other disease. Therefore, it is not dangerous to operate on these children but helpful. Of course we do not operate on the very sick child. I have yet to see a fusion operation that has had any serious effect on the general health of the child.

Dr. John Wilson, Los Angeles, Calif.: My interest in the surgical treatment of joint tuberculosis is entirely due to the enthusiasm of Dr. Hibbs. We began to fuse hips in 1923 shortly after a visit to his Clinic. He told me at that time that he was not certain how it could be done best, but he thought the proper approach to this joint would be by the extra-articular route. With that in mind, I returned home and attempted to fuse hips in various ways with a fair amount of success, until I stumbled upon what may be called ilio-femero-plasty.

The lateral surface of the ilium and capsule of the hip joint are exposed by the Smith-Petersen incision. The capsule is split parallel to the long axis of the neck of the femur. The capsule is then pushed away from its attachment to the superior half of the margin of the acetabulum. The epiphysis of the great trochanter with its muscular attachments is removed with a periosteal elevator, if ossification is not complete. A fan-shaped section of the outer table of the ilium is now separated with a thin, sharp osteotome. The base of the fan should be just above the margin of the acetabulum. By careful manipulation the iliac flap is turned over and placed in the previously prepared cleft in the greater trochanter. Care should be exercised not to fracture the iliac flap. When the wound is closed, the iliac periosteum lies against the raw surface of the ilium, and a solid triangular block of bone with its base at the neck of the femur is the result.

In the past five-year period we have done fifty-two operations. Two patients died, one from surgical shock and the other from generalized tuberculosis. Eight of these patients have been lost sight of and the remainder either have or are getting satisfactory fusions.

It is advantageous not to interrupt the blood supply of the flap. While this operation can be done at any age, it is most applicable to children. We have fused hips satisfactorily at three years of age. The younger the patient the more rapid the consolidation of bone. It is more difficult to turn back the flap in the adult. When adult life is reached, the distance between the great trochanter, the acetabulum, and the iliac crest increases, so that unless there is a fair amount of destruction of the head and neck of the femur, it is a little difficult to get the flap into the trochanter far enough to produce a good fusion.

The presence of sinuses is not a contra-indication to this operation. It is well to avoid them with the incision. Care must be exercised to allow the sinuses to drain, if possible, without contaminating the operative wound. Convalescence is, as a rule, rather stormy after operation in badly infected hips, but fusion may eventually be expected.

The principles of joint fusion as set forth by Dr. Hibbs represents the real progress of this generation in surgical treatment of joint tuberculosis.

Dr. C. F. Eikenbary, Seattle, Wash.: So far as the outlook of tuberculosis of the hip, knee, and ankle is concerned, I agree entirely with what Dr. Hibbs, Dr. Ryerson and Dr. Wilson have said. The opinion that I have in regard to tuberculosis of these various joints is one that has come about rather gradually and is the result of attempting over a rather long period of years to obtain movable joints by conservative treatment. The men who have spoken before me have expressed practically the same thought. As I look back over the cases that I tried to treat conservatively, the only cases that I know were cured were those that fused naturally and without any operative interference. The only cases that I think of that have recovered with useful motion are those in which I am now inclined to doubt the diagnosis.

I wonder a little bit whether the method of Dr. Hibbs or the method of Dr. Albee goes quite far enough. After seeing Dr. Hibbs' pictures I rather hesitate to mention this because his pictures are very convincing.

During the past five years we have seen a number of cases of tuberculosis of the shaft of the bone, tuberculosis of the tibia not involving the epiphysis, tuberculosis of the metacarpal and metatarsal bones, and one of the malar bone, all proved by guinea-pig tests. Those cases do not get well by any type of conservative treatment. They do get well when you institute surgical treatment and treat them as an ordinary osteomyelitis. They do not get well merely by fixation.

With the thought that we should do better, three or four years ago we began to do what we call an extra-articular and intra-articular fusion. That means going in by the ordinary Smith-Petersen incision, cleaning out all the pus and debris, then putting in a graft from the ilium, a little bit on the order of the graft Dr. Wilson has described, to a slot back of the trochanter. It is a very easy thing to do. We have done that in thirty-four instances. Of those thirty-four there are twenty-four that I can make some kind of a reasonable report on. Of the twenty-four, seventeen are cured; some of them have been cured a year, some two or three years. Perhaps it is not long enough, but it seems to us very well; certainly the union is solid. The average age of the children was nine and the oldest patient was fifty-two. This man had had the disease for thirty years and was under treatment all of that time. Fifteen of these cases had large abscesses. That is a point we might emphasize. In none of them did we have any breaking down of the tissue, so the presence of an abscess is certainly no contra-indication to the fusion operation. We have operated on four or five patients who had very large sinuses. These did not heal primarily. The period required for fusion was much longer.

Dr. Hibbs did not state, nor did Dr. Ryerson, nor Dr. Wilson how long it takes to get fusion. By our method it requires from three to eighteen months, the cases requiring eighteen months being those that have numerous sinuses. Several of these cases were out of all supports in three months' time. The average period of fixation was about five and one-half months. I would like to say that we have had no complications. In not a single instance have we failed to demonstrate the disease. We had one child die from tuberculous meningitis six months after the fusion was complete; this could hardly be considered as a complication of the operation itself.

I would be very much pleased if some of you would look at these pictures and tell me whether you think this method amounts to anything or whether you think I am doing too much.

Dr. Horace Lo Grasso (Closing discussion): We internists, whether justified or not, have a very grave sense of the insidious and dangerous character of tuberculosis, and approach it with extreme wariness. You surgeons apparently have no such compunctions and consider it as something very simple. You speak of lesions full of living tubercle bacilli, the incision of which would open up armies of infection; yet you mention no bad results. Evidently the intended inference is that in operating on bones and joints, metastases are not at all common; yet both theory and experience point to the conclusion

that one of the principal characteristics of tuberculosis is its aptitude to spread. In tuberculosis of the kidney, even a cystoscopic examination has produced a miliary tuberculosis.

In the absence of statistics showing the after condition of cases treated by surgery, I must rely on my own observations of patients who had been thus treated and subsequently came under my care. Fusions of the knee have been followed by death from advanced tuberculosis two or three months later. Miliary tuberculosis and meningitis are not uncommon consequences.

Of course, if Dr. Hibbs has been handling chiefly early cases where the diagnosis has to be made by biopsy, these bad results have probably been avoided; but in such cases conservative treatment would also give excellent results.

There seems to have been some confusion in the definition of terms. To some of you, conservative treatment apparently means ambulatory splinting; to me, it means heliotherapy, which implies absolute rest in bed and sun cure at the same time, a treatment fundamentally different.

The question of time was brought up, but until we have some accurate record of these cases for five or ten years after operation, we have no proper basis for comparison.

It has been contended that by treating the local lesion you are probably handling at the same time the focus of infection. The opposite is usually true. If you handle the focus of infection you will likely heal the local lesion. In a series of experiments made a few years ago to ascertain the connection between tuberculosis of the cervical glands and tonsillar tuberculous infection, it was discovered that while removal of the glands was useless, tonsillectomy apparently healed the glands.

We must not lose sight of the fact that sixty-five per cent. of bone and joint cases have pulmonary lesions also, and most of the deaths that take place following operation or even following heliotherapy are due, not to the local lesion, but to pulmonary tuberculosis.

REPAIR OF BONE IN THE PRESENCE OF ASEPTIC NECROSIS RESULTING FROM FRACTURES, TRANSPLANTATIONS, AND VASCULAR OBSTRUCTION*

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Aseptic necrosis of bone may result from a number of causes,—as vascular disturbances, injuries, the action of chemicals, and the application of radium in the treatment of malignant disease.

The process of repair of the damaged area differs with the causative agent and with the amount of functional stimulation to which the part is subjected during the reparative period. It also differs from that seen in case of necrosis produced by infection. Necrosis *en masse* produced by severe infection is nearly always followed by a fibroblastic and fixed tissue phagocytic reaction which usually results in complete absorption of the dead bone, if the area is small, or in sequestration, if it is large. However, mild inflammatory reactions, particularly when associated with embolic or thrombotic processes and due to low grade micro-organisms, may sometimes result in necrosis which is followed by simultaneous absorption of dead bone and incomplete, irregular replacement by new bone, as first pointed out by Axhausen[1]. This same change may also be observed in a bone graft when mild infection has occurred. It is not uncommon to see a portion of a graft, which has been exposed by opening of the wound with the escape of exudate, heal in and subsequently undergo transformation without sequestration. Epiphysitis may result in rather extensive necrosis which is followed by absorption and a certain amount of collapse and new bone formation with eventual bony reconstruction of a deformed epiphysis.

The introduction of radium into or in contact with bone in the treatment of malignant disease may lead to more or less extensive bone necrosis without destruction of the peripheral layer of the overlying soft parts, in which case the necrotic bone remains free from infection. The necrotic bone produced in this way may be sequestrated at a very slow rate or, if it performs a supporting function, it may be very slowly absorbed and replaced by new bone. If infection is present it is always slowly sequestrated. The explanation of the slow absorption is to be found in the fact that the tissues adjacent to the dead bone are radium burnt and consequently bring about repair very slowly. I implanted radium needles into an undifferentiated round-cell sarcoma of the ischium, producing aseptic bone necrosis, and after subsequent x-ray treatments saw healing of the sarcoma with repair of the

*Read before the American Orthopaedic Association, Chatham, Massachusetts, June 20, 1930.

bony defect without evidences of sequestration of the necrotic bone after the lapse of seven years. On the other hand in a case of undifferentiated round-cell sarcoma of the lower arm treated by excision, radium implantation in contact with humerus, and subsequent roentgen therapy, there was very slight infection in the field. In this case a large portion of the cortex which was killed by radium was very slowly sequestrated in the course of six years and at the end of eight years was still present as a loose piece which had worked out into the soft parts.

In experimental radium necrosis[2] the entire circumference of the shaft of the femur of the dog was killed by the insertion of radium into the medullary cavity downward from the trochanter. The dead bone was very slowly replaced but its fate was dependent to a considerable extent on the amount of function which the limb performed. Some animals walked on the limb for months without the occurrence of a fracture and without sequestration of the dead bone. There was very slow creeping substitution of dead bone by new bone from the two ends. After the lapse of months fracture sometimes occurred through the dead bone. If the fracture resulted in non-union so that the extremity was no longer used, there was gradual sequestration of the dead bone in the course of one to two years. If there was overriding of fragments and if portions of the two fragments that were undamaged by radium approximated each other, new bone was formed and the fracture united. If a portion of the necrotic bone was caught in the line of the new bone formed by unburnt tissues, it was rapidly absorbed and replaced by new bone. However, if the necrotic bone lay outside the callus and the line of stress and strain, it was very slowly absorbed without replacement by new bone.

Bancroft[3] produced chemical necrosis of bone experimentally in dogs by the introduction of croton oil into the medullary cavity. The inflammatory reaction set up by the oil resulted in a marked absorptive and osteoplastic process with sequestration and formation of an involucrum. Owing to the rapid disappearance of the inflammatory reaction, the reparative changes proceeded more rapidly than in case of necrosis produced by infection and in the course of a few weeks there was complete absorption of the dead bone with reformation of a new shaft.

INTERFERENCE WITH CIRCULATION

The fate of bone which undergoes aseptic necrosis as a result of circulatory disturbance varies considerably, according to the environment of the necrotic area. If the necrotic bone is attached to and directly continuous with living bone, there is ingrowth of vessels and of fibrous and osteogenic tissues from the living into the necrotic area. There is usually survival of unossified osteogenic elements about the periphery and ends of the area that has had its circulation interrupted. By the process of creeping substitution the old bone is gradually absorbed and replaced by new bone, so that in the course of months or occasionally years the necrotic area is

FIG. 2

Case 1. Twenty days after arthroplasty.

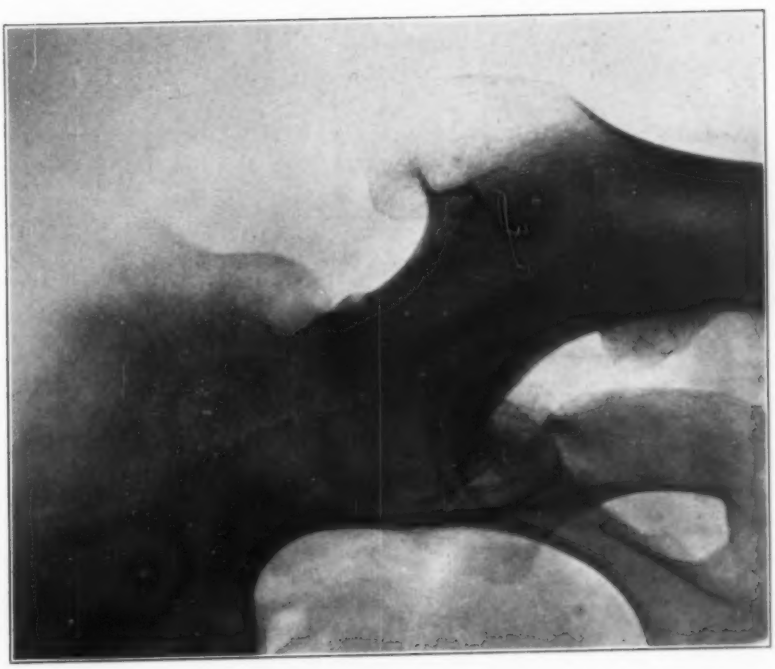

FIG. 1

Case 1. Bony ankylosis following pyogenic arthritis.

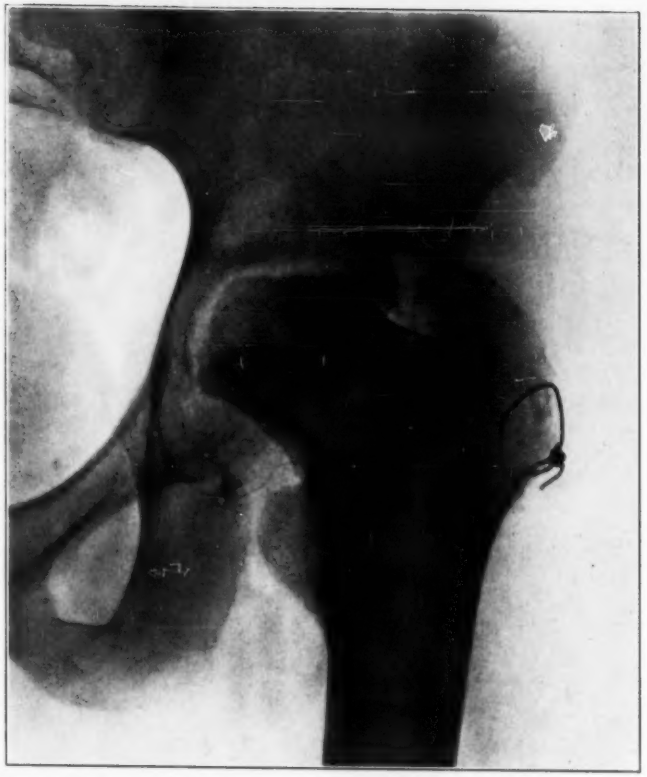

FIG. 3

Case 1. Thirty-six days after arthroplasty. Beginning reduction in density in base of neck and shaft. No change in head.

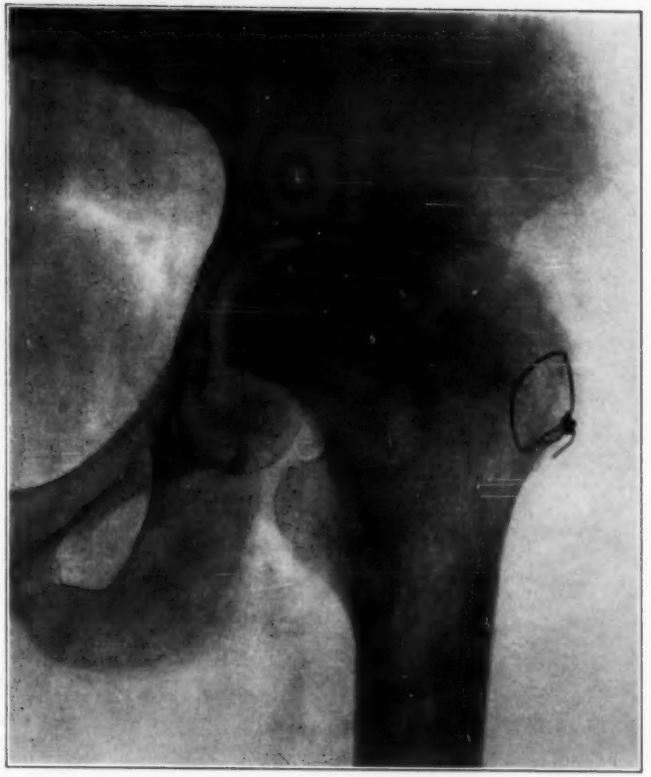

FIG. 4

Case 1. One hundred and fifty-one days after operation. Density of necrotic head unchanged but shaft and pelvis show atrophy of disuse.

more or less completely transformed into a living one. Whether the amount of new bone formed is as great as the amount of bone which died depends largely on the extent of living bone with which it is in contact and the amount of osteogenic elements surviving about its periphery. When these are both extensive, there may be complete replacement of the dead bone by new bone; but when limited, bone absorption may be greatly in excess of bone formation, so that incomplete replacement results with the formation of bone that is less dense than the original and that shows varying degrees of cavitation. Functional stimulation also plays an important rôle in the rate and degree of transformation. In general the greater the degree of function, the greater the rate and degree of transformation into new bone. If the necrotic bone is largely or wholly intra-articular and extensively bordered by articular cartilage, the attachment to the surrounding soft parts will be markedly limited and chances for revascularization and transformation will be greatly reduced. Thus, injury to vessels may be the cause of some of the cases of Kienböck's malacia of the carpal lunatum and of Legg-Perthes' disease,—as when it follows reduction of congenital dislocation of the hip.

OPERATIVE INTERFERENCE WITH THE BLOOD SUPPLY

Operations which involve severence of bone or extensive separation of soft parts from bone may occasionally interfere with blood supply sufficiently to cause massive necrosis. An example of this is the necrosis of the head and neck of the femur in the following case in which arthroplasty of the hip was performed.

Case 1. Male, age twenty-eight, entered the University of Chicago Clinics May 7, 1929, because of bony ankylosis of the left hip resulting from acute hematogenous pyogenic arthritis two and one-half years previously (Fig. 1). At operation on May 9, through a goblet incision the greater trochanter was reflected, the soft parts reflected from the neck, and the head detached from the acetabulum with a chisel. After roughly rounding it off and deepening the acetabulum, a cap of free fascia lata was placed over the head and tied about the neck with a purse-string suture of chromic catgut. The head was then restored to acetabulum, the muscles and greater trochanter were sutured in place, the wound closed, and a body and leg cast applied. There was slight postoperative febrile reaction, but the temperature returned to normal at the end of ten days and the wound healed with only a slight superficial serous discharge. The cast was removed after two weeks and weight extension applied for ten days. A roentgenogram taken twenty days postoperatively (Fig. 2) showed the reduced head of the femur with its sharply outlined chisel cuts resting in the acetabulum. Movement was begun and after five weeks the patient was allowed to walk with crutches. In a roentgenogram taken thirty-six days postoperatively (Fig. 3) the head and neck showed their outline and density unchanged, but there was a slight reduction in density in bone at the junction of neck and shaft and slight atrophy of disuse of the shaft. A fair range of mobility persisted in the hip but it remained painful so that the patient continued to walk on crutches. A roentgenogram taken 151 days postoperatively (Fig. 4) showed the head retaining its original density and sharp outline of its cut surface. The adjacent innominate bone and the trochanters and shaft of the femur showed marked atrophy of disuse. The zone of reduced density at the base of the neck had broadened to include almost the entire neck

FIG. 5

Case 1. Two hundred and fifty days after operation. Head extensively reduced in density from invasion and replacement from the living bone of base of neck.

FIG. 6

Case 1. Four hundred and four days postoperative Cavitation at base of head and further transformation.

of the femur. A diagnosis was made of necrosis of the head and neck of the femur with retention of the original density of the head and atrophy of disuse of the surrounding living bone. The extension of the rarefaction in the neck was interpreted as evidence of beginning invasion of the necrotic portion by tissue from the living portion with absorption of the dead bone and replacement by a less dense living bone. The hip improved slowly and the patient began to bear a small amount of weight on it. A roentgenogram 250 days postoperative (Fig. 5) showed persistence of the atrophy of the shaft and innominate bone and a very marked reduction in the density of the shadow cast by the head as compared with the previous roentgenograms. The cortex at the inferomesial and superolateral portions of the base of the head retained its old density but the cancellous bone of the interior and articular surfaces of the head had been reduced to practically the same density as the trochanters and upper end of the shaft. This was interpreted as evidence of extensive invasion of the head with absorption of the dead bone and a certain amount of replacement by new bone. The patient then made greater use of the limb in weight-bearing but continued to assist it with a crutch. A roentgenogram taken 350 days after operation showed slight increase in density of all of the atrophic living bone in the region and slight further reduction in the dense areas of the head. The patient then walked with the assistance of a cane, and a roentgenogram taken 404 days postoperatively (Fig. 6) showed little change except for evidence of cavitation in the inferomesial part of the head, indicating absorption of the necrotic bone with failure of replacement by new bone.

The hip showed about forty degrees of flexion but marked limitation of abduction and rotation. Its strength had gradually improved and there was only slight discomfort in walking unless it was prolonged.

The cause for this exceptional occurrence of necrosis of head and neck without sequestration appeared to lie in the traumatism of head and denudation of neck of its covering of soft parts. However, it may have been due in part to deep-seated mild infection in the region of the new joint, despite the absence of discharge from that region. Failure of the necrotic head to be sequestrated speaks decidedly in favor of aseptic instead of septic necrosis although sequestration may not occur in the presence of mild infection of a necrotic area. In another case I observed necrosis of the head and neck following an arthroplasty in which there was infection of the wound with a purulent discharge, but the dead bone was sequestrated in the course of several weeks. In the case here reported functional stimulation of the bones resulting from movement of the joint, combined with protection of the necrotic head from weight-bearing, was followed by creeping substitution of the necrotic bone by new bone in the greater part of the head without either erosion of dead bone or the development of marked deformity.

Extensive separation of periosteum from bone, particularly during the growing period, with resultant injury of nutrient and metaphyseal vessels may result in extensive aseptic necrosis of bone. Brunschwig of the University of Chicago has produced areas of necrosis in the femur and tibia of young dogs varying up to nearly the entire extent of the shaft. There is absence of sequestration, and creeping substitution of the necrotic bone takes place by new bone, formed from the adjacent living bone and the surviving osteogenic elements of the separated bone and periosteum with only slight changes in size, shape, and density. Such bone necrosis is

no doubt occasionally produced by extensively denuding operations, but it remains undetected as the damaged area is repaired without appreciable alteration in the clinical course of the disease.

NECROSIS IN FRACTURES

Fracture may cause necrosis by interference with the blood supply of the bone in the immediate vicinity of the break or by damage to larger vessels that furnish a large part or all of the nutrition to one of the fragments.

Cornil and Coudray[5] found that in experimental fractures there is necrosis of the cortex for a variable distance back from the fragment ends which is gradually replaced by new bone ingrowing from the living cortex with which it is continuous and to a less extent from the adjacent callus. This occurrence does not interfere with the process of healing. In fact, it has even been claimed that the presence of the necrotic bone is a stimulus to bone repair. Non-union and neck absorption in fractures of the femoral neck have probably been wrongly attributed to the marginal necrosis of fragment ends. Clinically I have not seen evidence of any appreciable amount of bone necrosis extending back into the fragment ends from the fracture line, either at operation or in roentgenograms. A narrow strip of fragment end may be bare and white when a simple fracture of some standing is exposed at operation; but I have never seen the fragment ends appear appreciably denser than the cortex some distance back from the fracture as shown by roentgenograms of fractures, either united or ununited, of several weeks' standing, where the regional bone had undergone atrophy of disuse. The indications are that such bone as becomes necrotic at the ends of vascularized fragments is rapidly revascularized by ingrowth from the living bone and is absorbed and reduced in density about as rapidly as is the adjacent living bone from atrophy of disuse. In histological sections of resected ends of fragments from cases of delayed union or non-union, I have not seen extensive amounts of dead bone and that which I have found showed signs of creeping substitution by new bone.

In the case of fractures followed by bony union, marginal necrotic bone may rarely be absorbed more rapidly than new bone is deposited, thereby creating a zone of reduced density in the region of the fragment ends. It is seen in pathological fractures of osteomalacia, osteogenesis imperfecta, and in bone diseases associated with parathyroid adenoma and is known in the German literature as Losser's *Umbauzone*[6] (zone of transformation). I saw it once in a patient who had no general bone disturbance but a refracture of the ulna one year after the original fracture had been successfully treated by an autogenous inlay bone graft. Following the refracture a second bone graft was inserted in the accompanying fractured radius which had failed to unite following the first transplantation. Three and one-half months afterwards the radius was united, but a zone of reduced density had developed along the oblique fracture line in the ulna although no motion could be elicited. Six and a half months later the zone was

slightly narrowed and increased in density and eleven months later it had fully ossified. This zone apparently resulted from absorption of marginal necrotic bone produced by the fracture with marked delay in replacement by new bone for some unexplained reason.

BONE NECROSIS IN JOINT FRACTURES

Necrosis of bone may also occur in fractures bordering on joints from injury to the blood vessels to a large part or all of the joint fragment. It undergoes either partial or total necrosis. The condition may be met with in intracapsular fractures of the neck of the femur, of the capitellum humeri, of the carpal navicular, of the head of the radius and of the neck of the astragalus, and it always follows complete detachment of small fragments in intra-articular fractures.

FIG. 7

Necrotic femoral head casting heavier shadow than surrounding atrophied living bone.

Necrosis of the proximal fragment in complete intracapsular fracture of the neck of the femur occurs in a not inconsiderable percentage of the cases. Santos[7] has recently completed a detailed study which has thrown light on many aspects of the condition. A summary of his report follows: Necrosis may occur in fractures at any age, and although relatively more frequent in older persons, it is often absent in them. This may sometimes be because of blood reaching it by way of vessels in the untorn periosteum. The vessels of the ligamentum teres may supply adequate blood to keep the head alive even in the aged.

Death of the proximal fragment predisposes to non-union, but union occurs in a considerable percentage of the cases with a dead head in which there is impaction of fragments or in which there is efficient reduction and fixation of fragments, the best results apparently being obtained from the closed abduction method of Whitman. At the end of the period of immobilization the distal living fragment usually shows roentgen-ray signs of reduced density due to atrophy of disuse, but the necrotic head which cannot atrophy casts practically as even and heavy a shadow as at the time of fracture. This usually makes it possible to diagnose necrosis roentgenologically at this stage.

FIG. 8

Roentgenogram of slice of excised head in Fig. 7, showing old necrotic bony trabeculae still undisturbed.

If bony union occurs the head is gradually invaded by the ingrowth of tissue from the distal fragment and sometimes from the hypertrophied round ligament. The necrotic marrow is replaced by vascular connective tissue and eventually by bone marrow, but the necrotic bone is much more slowly absorbed and replaced by a variable amount of irregularly arranged living bone. The necrotic cartilage is slowly absorbed and replaced by fibrous tissue, fibro-cartilage, and to some extent eventually by new hyaline cartilage. If too much weight is borne on the head before it has been transformed into new bone, its weight-bearing portion may collapse with a resultant deformity and a poor functional result, but this may be averted by prolonged avoidance of weight-bearing. The functional stimulation which comes from motion of the limb without weight-bearing is sufficient to hasten transformation of the head.

If non-union results, the neck fragments are gradually more or less completely eroded and the remaining surfaces usually become more or less adherent to the capsule and to each other. The marrow spaces of the dead and non-functioning head are gradually invaded by vascularized connective tissue by way of the round ligament and in some cases by way of the adhesions. Absorption of the invaded old bone and partial replacement by new bone either does not take place at all, at least for many months, or it

goes on very much slower than is the case when bony union takes place and the head is subjected to functional stimulation. The head casts a shadow for at least one to two years that is denser than that of the neighboring living bone which is atrophic from disuse. These points are illustrated by Figure 7 showing a dense necrotic head in a case of ununited fracture of the neck of the femur of sixteen months' duration and by Figure 8 which is a roentgenogram of a slice of the excised head. Although both bone and marrow were dead and about one-half of the marrow space was reinvaded by connective tissue from the round ligament, there was no absorption of the dead bone except about the fovea, where there was also a small amount of newly formed bone. Eventually absorption and partial replacement of the dead head by new bone is brought about and the head may remain as a cavitous hull or in rare cases it may be completely absorbed. The bearing of these findings on prognosis and treatment are brought out in Santos's article.

FIG. 9

Case 2. Seventy-four days after fracture of neck of astragalus, posterior dislocation of body, and reduction by operation. Body necrotic and retained normal density. Atrophy of disuse of other bones. Bony union of fracture.

NECROSIS OF OS CALCIS

In fracture of the neck of the os calcis the body may rarely have so much of its blood supply cut off that it undergoes extensive necrosis. Its subsequent history is analagous to that of a necrotic proximal fragment in intracapsular fracture of the neck of the femur. If bony union between the fragments follows, the necrotic body will be invaded gradually by blood vessels, fibrous, osteogenic, and myelogenous tissue, and a gradual replacement of the necrotic by living elements will be brought about. The replacement may be incomplete and the necrotic portion located farthest from the fracture may be broken down by weight-bearing before the ingrowing tissue reaches it, thereby leading to deformity and permanent derangement of the bone.

The following cases are illustrative of this condition.

CASE 2. Male, aged twenty-six, sustained a fracture at the junction of body and neck of the astragalus with complete dorsal dislocation of the body, the posterior capsule

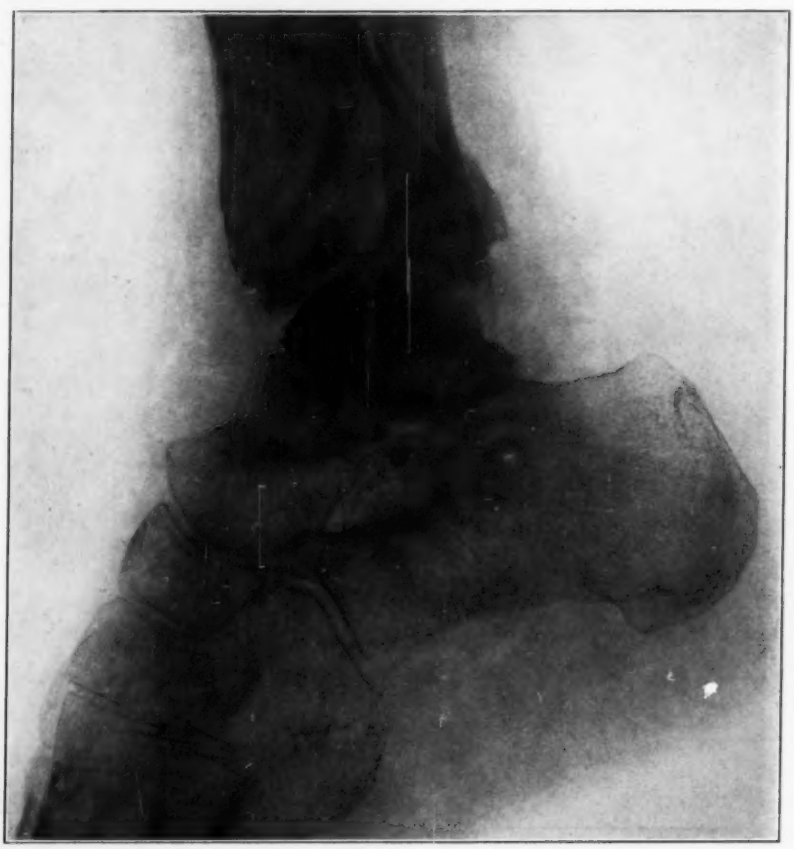

FIG. 10

Case 2. One hundred and sixty days after fracture. Body slightly reduced in density near fracture due to invasion from neck.

being the only remaining attachment. It was reduced by open operation and a cast applied which was worn for nine weeks. A roentgenogram taken seventy-four days after injury (Fig. 9) revealed marked reduction in density of the bones of the foot and the vicinity of the ankle, except the body of the astragalus which cast a shadow of normal density. The fracture appeared to be uniting, but the fracture line on the body fragment was irregular and worm-eaten, indicating invasion and absorption by tissue from the distal fragment. The diagnosis was made of aseptic necrosis of the body of the astragalus as indicated by the preservation of its normal density while the surrounding bone underwent atrophy of disuse. The patient had stiffness and weakness in the ankle and walked with crutches. A roentgenogram taken 160 days after injury revealed appearance of further invasion and reduction in density of the body of the astragalus with preservation of its bony articular cortex (Fig. 10). The patient was then lost sight of.

Case 3 is that of a five-year old boy who fell twenty-two feet, sustaining a fracture at the junction of the neck and body of the left astragalus with little displacement of fragments and a fracture of the posterior superior portion of the os calcis (Fig. 11). A foot and leg cast was worn for six weeks, after which the patient gradually began to walk on the limb; but stiffness and pain persisted, causing a considerable amount of disability. A roentgenogram taken 274 days after the injury (Fig. 12) showed union of the fractures in both astragalus and os calcis but the body of the os calcis had undergone extensive change. There was irregular increase in density of the distal and inferior portion of the proximal fragment, which was due to newly formed bone, but the superior and posterior portions bordering on the ankle joint were reduced in volume and irregularly in density, and the shadow of articular surface was lost in almost its entire extent. There was a small island of bone in the posterior articular portion of the body. The body had apparently become necrotic; its distal portion had been invaded and replaced by new bone, but the articular portion had broken down from weight-bearing, before being invaded and partially absorbed by vascularized connective tissue. Walking was continued with little improvement of symptoms. A roentgenogram taken fourteen and a half months after the injury showed still further irregularity and reduction in volume of the body of the os calcis. Eighteen months after the injury (Fig. 13) there was little change in appearance except that the island of bone posteriorly had increased considerably in size. Another roentgenogram twenty-three months after injury showed the changes in the body had remained practically stationary, but the articular surface was more regular in outline. The island of bone in the posterior part of the body was interpreted as a transformed necrotic portion that had become revascularized with gradual growth of the bony center.

The blood supply of the astragalus is derived mainly from a branch of the arteria dorsalis pedis which traverses the sinus tarsi lateral to the neck and breaks up to enter the bone near the junction of the neck and body along the lateral and inferior surfaces. There are very small branches entering the bone mesially and posteriorly at points of ligamentous and capsular attachments. Apparently when there is a fracture along the junction of body and neck the important vessels to the body are interrupted and there may be insufficient circulation through the remaining vessels, so that aseptic necrosis of a large part or all of the fragment follows. It is evident from the partial collapse which occurred in Case 3 that when necrosis of the body is diagnosed, the limb should be protected from weight-bearing for at least several months,—until union, revascularization, and transformation of necrotic area has been largely brought about. It seems probable that some of the bad results that have been reported in fracture of the neck

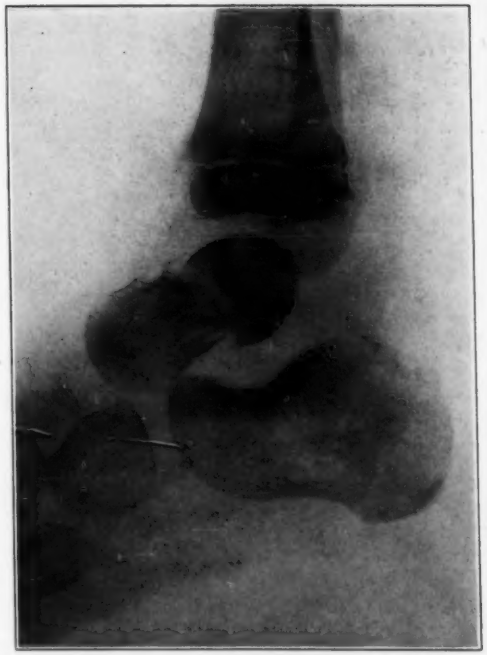

FIG. 11

Case 3. Fresh fracture of neck of astragalus and chip off superior and posterior portion of os calcis.

FIG. 12

Case 3. Two hundred and seventy-four days after injury. Fracture of astragalus united. Superior and posterior part of body broken down and irregular while remaining portion dense and transformed. Indicative of necrosis of body with secondary changes.

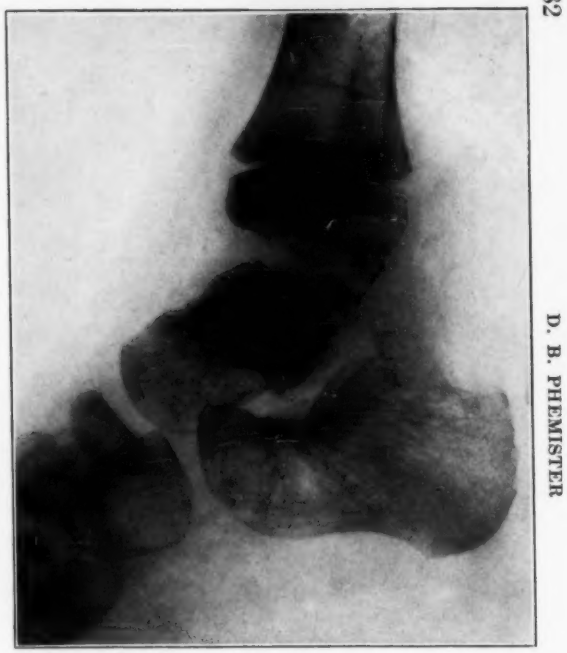

FIG. 13

Case 3. Eighteen months after injury, showing a defective but gradually reforming articular portion of the body of the astragalus.

of the astragalus, either united or ununited, have been due to overlooked aseptic necrosis of the body.

BONE TRANSPLANTS

Nearly all of the more recent studies tend to confirm the view that when bone is transplanted the bone cells within the lacunae practically all become necrotic as a result of cutting off of the circulation. The unossified osteogenic elements along the periphery and in the vascular canals may survive. The extent to which they proliferate and take part in the transformation of the necrotic bone depends to a considerable extent upon the location of the transplant and the extent to which it is subjected to functional stimulation. If the transplant is in the course of a bone, with the fragments of which it should become united in order that the continuity of the bone be restored, and as a part of which it should function, the surviving osteogenic elements proliferate and take an active part in osteosynthesis and transformation of the necrotic portion of the graft. Osteogenic elements of adjacent bone also participate and more recent studies as those of Baschkirzew and Petrow[8], Leriche and Policard[9], and Kartaschew[10],

FIG. 14

Case 4. Large splinter (*a*) displaced into soft parts from fresh fracture of tibia.

FIG. 15

Case 4. The same (*a*) seven years later, showing reduction in size of splinter and apparent replacement by very spongy new bone.

indicate that fibrous tissue invading aseptic bone may be gradually transformed into bone. That this is not the source of any considerable amount of new bone replacing the dead bone is shown by the observations of Santos that a necrotic head in ununited fracture of the femoral neck is very little replaced by new bone by metaplasia of invading connective tissue from the round ligament. If the transplant is in the soft parts, disconnected with the skeleton and serving no supporting function, the surviving unossified osteogenic elements about the ends may proliferate temporarily,—as in the healing of a fracture of a bone graft as shown by Haas, or in closing the open end of the medullary cavity of the graft as shown by Phemister. But soon resorptive activities are found to exceed proliferative activities and

FIG. 16

Case 5. Tibial graft thirty-nine days after insertion in humerus.

FIG. 17

Case 5. Ten years and eight months after operation. Shows non-functioning portion of graft in medullary cavity practically unchanged, but the functioning portion above hypertrophied and transformed.

the fragment begins to decrease in volume. It may eventually be entirely removed in the course of months or years, depending on the size of the fragment, or the remnants of the mass after years may consist largely if not entirely of spongy new bone. Thus, a large splinter of cortex in a fracture of the tibia displaced dorsally into the soft parts is shown in a roentgenogram taken shortly after the injury (Fig. 14). The fracture, united in malposition, was successfully treated by open operation, but the fragment was left undisturbed. Two years later its shadow was about one third the original size. Seven years later it was reduced to a small spongy oval mass (Fig. 15) which roentgenologically has the appearance of living bone.

In case a bone graft of the whole thickness is transplanted into a defect in a bone and anchored by insertion of one end into the medullary cavity, the subsequent changes in the intramedullary and extramedullary portions are different, due to some extent to their differences in function. After union occurs the extramedullary portion may hypertrophy and gradually be completely transformed into living bone which may approach the shape and size of the missing portion. In adults the rate of transformation is slower and the extent less than in children. A striking finding is the relatively small amount of absorption which goes on in the non-functioning portion of transplant which lies within the medullary canal beyond the point of union with the end of the cortex of the host. Such bone may present practically the same roentgenological appearance for many years. Figure 16, Case 5, shows a broad graft of tibial cortex seen on edge, thirty-nine days after transplantation for replacement of the upper end of the humerus, excised because of a small chondrosarcoma, in a man twenty-two years old. Figure 17 shows the same ten years and eight months later, there being no recurrence of tumor in the meantime. The extramedullary portion of the graft has become slightly enlarged and rounded off and possessed of a small medullary cavity in its upper third. New lamellae have formed in its cortex. The intramedullary portion below the level of union with the end of the humerous is almost unchanged. However, I have examined a specimen of fibula transplanted eighteen months previously in precisely the same way to replace the upper end of the humerus excised for osteogenic sarcoma. Amputation was performed because of recurrence of the tumor. The extramedullary portion which was largely surrounded by tumor was about one third replaced by living bone. The intramedullary portion was porous and on histological examination showed some absorption with very little replacement by new bone, suggesting that eventually it would have been transformed. In contrast with these slow changes in non-functioning intramedullary grafts is the rapid absorption which a non-functioning piece of bone in soft parts undergoes, as shown by Case 4.

EMBOLISM AND NECROSIS

The etiology of the lesions dealt with up to this point has been clear. The rôle of embolism in the production of both septic and aseptic bone necrosis is still imperfectly understood. Ritter, Winkebauer and Axhausen[11]

have expressed the belief that in pyogenic osteomyelitis the extensive necrosis of bone is the result of septic embolism cutting off the blood supply of large areas at the onset of the process with subsequent invasion and infection of the infarcted area by bacteria from the embolus. This view is inconsistent with our knowledge of the blood supply of the cortex of the shaft of bones. The experiments of Johnson[12] showed that the periosteal vessels supply approximately the external half, while the internal half is supplied by the nutrient artery and metaphyseal vessels. Injury of either set of vessels results in necrosis of much of the bone which they supply. Now the dead bone in osteomyelitis is not limited to the region supplied by one or the other of these sets of vessels. While an embolus might account for extensive necrosis in the region supplied by the nutrient artery, this would be impossible in the regions supplied by the periosteal vessels since they are numerous and small. Usually the entire thickness of cortex of the involved region becomes necrotic. Also in primary and especially in recurrent osteomyelitis the infection may be observed, starting at one limited point and spreading more or less extensively to the rest of the bone.

Aseptic necrosis of bone, the result of proven thrombosis or embolism, is a condition that has been rarely reported in man. Axhausen[11] reported a case which was classed as multiple anaemic infarction of bones, but streptococcus longus anhemolyticus was cultured from the lesions. Consequently it is incorrect to speak of the condition as aseptic necrosis of bone.

Aseptic necrosis has been produced experimentally by injection of small aseptic emboli into the femoral artery. The infarcts formed in the ends of the shafts and rarely comprised a large part of the diaphysis, but epiphyseal necrosis was not produced. A marked osteoblastic reparative reaction developed about the necrotic bone which was rapidly replaced by new bone by the process of creeping substitution. The so called necrosing lesions of the center of ossification of certain epiphyses in children and the os lunatum in young adults have been variously attributed to injury to the blood vessels, vascular obstruction from embolism or thrombosis, and infection.

Thus Legg-Perthes' disease sometimes follows reduction of congenital dislocation of the hip which points to vascular injury and the experiments of Nussbaum[13] show that cutting epiphyseal vessels results in necrosis followed by reorganization and deformity of the bony center. Phemister, Brunschwig, and Day[14] have cultured biopsied specimens from two cases each of Köhler's disease of the tarsal navicular bone, Legg-Perthes' disease, and Kienböck's disease of the os lunatum. They found that streptococci grew in cultures of four, and the indications are strong that this organism is the etiological factor in some cases. In one case of Köhler's disease and in one of Legg-Perthes' disease the cultures remained sterile, although the case of Köhler's disease was associated with multiple osseous and lymph glandular tuberculosis. Histologically there was necrosis but no sign of tuberculosis in the navicular; consequently the case supports the theory of Axhausen that a caseous tuberculous embolus may be a cause of the necrosing lesions.

Histologically the majority of these lesions appear to have something more back of them than a simple bland embolus or injury cutting off the circulation and producing aseptic necrosis. As previously stated, aseptic necrotic bone in continuity with living bone is gradually invaded and more or less completely replaced by new bone through the process of creeping substitution, unless it is too inaccessible and is broken down by traumatism. In these diseases there is a marked fibroblastic and fixed tissue phagocytic reaction and, in rare cases, an infiltrative reaction which result in absorption of necrotic bone without bony replacement by creeping substitution except in occasional instances. New bone formed from surviving osteogenic elements replaces more or less completely the absorptive tissues in the course of time.

BIBLIOGRAPHY

1. Axhausen, G.: Knochennekrose und Sequesterbildung. Deutsche Med. Wchnschr., XL, 1, 111, 1914.
2. Phemister, D. B.: Radium Necrosis of Bone. Am. J. Roentgenol., XVI, 340, 1926.
3. Bancroft, F. W.: Bone Repair Following Injury and Infection. Arch. Surg., V, 646, 1922.
4. Brunschwig, A.: Experimental Infarction of Bone Marrow. Proc. Soc. Exper. Biol. and Med., XXVII, 1049, 1930.
5. Cornil, V. and Coudray, P.: Du Cal. Au Point de Vue Expérimental et Histologique. J. de l'Anatomie et de la Physiologie, XL, 113, 1904.
6. Looser, E.: Über Spätrachitis und Osteomalacie. Klinische, röntgenologische und pathologisch-anatomische Untersuchungen. Deutsche Ztschr. f. Chir., CLII, 210, 1920.
7. Santos, J. V.: Changes in the Head of the Femur after Complete Intracapsular Fracture of the Neck: Their Bearing on Non-union and Treatment. Arch. Surg., XXI, 470, Sept. 1930.
8. Baschkirzew, N. J., und Petrow, N. N.: Beiträge zur freien Knochenüberpflanzung. Deutsche Ztschr. f. Chir., CXIII, 490, 1911–1912.
9. Leriche et Policard: Les Problems de la Physiologie normale et pathologique de l'Os. Paris, Masson et Cie, 1926.
10. Kartaschew, S. I.: Beiträge zur Frage der freien autoplastichen Knochentransplantation. Experimentelle Untersuchungen mit besonderer Berücksichtigung der Transplantation feiner Knochenstückchen und -splitter. Arch. f. klin. Chir., CLVI, 758, 1930.
11. Axhausen, G.: Über anämische Infarkte am Knochensystem und ihre Bedeutung für die Lehre von den primären Epiphyseonekrosen. Arch. f. klin. Chir., CLI, 72, 1928.
12. Johnson, R. W.: A Physiological Study of the Blood Supply of the Diaphysis. J. Bone and Joint Surg., IX, 153, Jan. 1927.
13. Nussbaum, A.: Die arteriellen Gefässe der Epiphysen des Oberschenkels und ihre Beziehungen zu normalen und pathologischen Vorgängen. Bruns' Beiträge z. klin. Chir., CXXX, 495, 1923–1924.
14. Phemister, D. B., Brunschwig, A., and Day, L.: Streptococcus Infections of Epiphyses and Short Bones and their Relation to Legg-Perthes' Disease, Kienböcks Disease and Köhler's Disease of the Tarsal Navicular. J. Am. Med. Assn., XCV, 1930, (in press).

CALF-MILT DIET IN THE TREATMENT OF SUPPURATIVE TUBERCULOSIS OF JOINTS

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The treatment of joint tuberculosis complicated by fistulas is a difficult problem. The appearance of a fistula in the course of the disease is a serious complication because of the danger of mixed infection. In a large number of cases it decides the fate of the patient, or there remains an obstinate, prolonged suppuration and amyloidosis. Especially obstinate are the cases with "late suppuration", often appearing many years after the active stage of the tuberculosis, when the diseased joint shows no clinical or radiological signs of activity, when the local process is free of symptoms, and the x-ray indicates a consolidation of the tuberculous area. There may be somewhere a very small destructive focus causing the suppuration. In these cases the purely orthopaedic measures are insufficient, as well as other customary therapeutic measures, as heliotherapy and x-ray therapy. This statement does not deny the value of heliotherapy or x-ray therapy in the treatment of tuberculosis of the joints, especially the suppurative kind; on the contrary, these therapies are among our most valuable and important means in the war against tuberculosis.

Seen from the pathological point of view, our therapeutic measures should aim to change the destructive type from an inflammatory into a productive type, which means tissue healing. Mineral salts are necessary to this constructive process, but, as the French emphatically state, the demineralization seems to be the impediment, although this claim of demineralization is not accepted by all authors. However, we must admit disturbance in the mineral metabolism, considering the lack of silicates in the tuberculous lungs. We use silicates as therapy in these cases, as it seems that the tissue infected by tuberculosis has lost the ability to take up and to accumulate mineral salts, similarly as in rickets the system is not able to assimilate the phosphorus in the blood. Regarding these facts, it can be understood why the only specific serological treatment used in tuberculosis of the joints does not suffice.

In the war against the micro-organism and its toxin, our aim must be to increase the resistance of the tissue.

With our present knowledge of the function of the spleen, it appears that the spleen has an active influence against infection, that the milt produces the antibodies, takes part in the mineral metabolism, and is in close correlation with the endocrine system. According to A. Meyer, the spleen takes over the function of the thymus as soon as this gland comes to the stage of

FIG. 1
Case 1, J. T. Before the treatment.

regressive metamorphosis; and we find in the literature a large number of clinical and experimental observations demonstrating the influence of the spleen upon the ossification. When the function of the milt is stopped there results a disturbance of the ossification (Meyer, Noetzel, Eliot). Mendel attempted to treat rickets by administration of thymus, and it was interesting to find an improvement in the rickets, by administration of thymus insets and calf milt simultaneously. Schröder and his pupils have studied the influence of the spleen in cases of experimental tuberculosis. They arrived at the conclusion that the milt is of distinct importance as protector against the tuberculous infection; the milt of rabbit and calf possesses immunity bodies against the human tuberculous bacillus. Schröder's histological pictures of animals infected with tuberculosis, and treated by milt, show the beneficial influence of the spleen in the treatment of tuberculosis. The tuberculous foci are incapsulated, the connective tissue around the foci very proliferated.

Moreover, as far as iron is concerned, the dependence of the mineral metabolism on the function of the spleen has been proved already. Harrower has demonstrated that the calcium of the blood increases under the influence of an extract of milt.

These facts seemed to justify an attempt to treat tuberculosis of joints by administration of raw, fresh calf-milt substance. It was found necessary to administer the substance in as natural a state as possible; otherwise, some substances on which the success of the treatment depends may be lost. While the active principle of the milt is not known, it is necessary to avoid too much heat in the preparation. The following methods of administration have proved satisfactory:

1. Raw calf milt, skinned and chopped, with hot beef soup poured over it.

2. Raw calf milt, skinned and chopped, mixed with vegetables.

3. Raw skinned and chopped calf milt mixed with spices, flour and egg, and fried in grease sufficiently only to obtain a brown surface.

4. Dr. Ropschitz, an Italian physician, has administered finely chopped milt in wafers.

There are also other ways to improve the taste, but the most important

precaution is to avoid too long cooking,—to use the spleen in as raw a state as possible.

Fifty to one hundred grams (one and one-half to three and one-half ounces) are given daily for four weeks, followed by intermission of fourteen days; and then the same administration is repeated. In serious cases it may be necessary to repeat this course several times.

The milt treatment has been used in the severest cases, in which other usual treatments had not been successful. Some were cases with suppuration and fistulas of long duration, frequently with mixed infection and with several foci. The results can be summarized as follows:

1. Rapid fall in temperature.
2. Diminution of suppuration.
3. Clearing of the tuberculous ulcer. In usually eight to fourteen days fresh and healthy granulations appear, the coated base becomes clean, the fistula commences to close from the base and from the edges.
4. Disappearance of the oedema surrounding the fistula.

FIG. 2

Case 1, J. T. Before the treatment.

5. Disappearance of the pain and hypersensibility of the joint.

6. An enormous improvement in the general condition, improved facial color, improvement of appetite, increased weight; simultaneously, improvement in the blood composition.

The x-ray does not show this early clinical improvement immediately, but is more slow in showing the improvement.

At the time of these experiments, I did not know of the similar work which had been done prior to mine, but later found that my observations agree for the most part with those of Dr. Bayle (Cannes) who first (1903) called attention to the importance of the spleen in cases of tuberculosis. He produced an extract of pig milt for oral and hypodermic administration. He reported excellent results in the treatment not only of tuberculous joints but also of other organs. Stimulated by my statement in 1928, Dr. Saxl (Vienna) obtained the same results in his control experiments, using fresh and raw calf milt. Dr. Hutter demonstrated during the past year, to the

FIG. 3

Case 1, J. T. Eight and one-half months after the beginning of the milt treatment.

FIG. 4

Case 2, C. W. Before the beginning of the treatment.

FIG. 5

Case 2, C. W. After three months of milt treatment. The disappearance of the swelling of the joint, except for a small portion, is evident. The surfaces of the bones of the joint show a good cortical wall.

FIG. 6

Case 3, J.M. Before the treatment.

FIG. 7

Case 3, J.M. After six months of milt treatment.

FIG. 8

Case 3, J.M. Six months after the beginning of the milt treatment. The child stands and walks with apparatus.

Laryngological Society of Vienna, a case of tuberculosis of the larynx treated by this method with marvelous success. In Switzerland, Ruttgers and Kamsler (1928) treated the pulmonary tuberculosis with raw milt diet and also reported good results. Loeffler, of Heidelberg (1928), has used this method with calf-spleen extract for oral administration in cases of tuberculous joints and has been able to report satisfactory results.

Although the treatment by spleen diet has had its failures, nevertheless a cure or an improvement can be obtained in a great number of cases where the other usual treatment is unsuccessful. The harmlessness of the treatment recommends its trial in every case, but especially in serious ones. Finally, it must be mentioned that the necessary orthopaedic treatment has not been neglected.

Illustrative cases treated by milt diet:

CASE 1. J. T., twenty-four years old, ill one and one-half years (Figs. 1, 2, and 3). Diagnosis: Tuberculosis of the ankle with fistulas. Extensive swelling of the foot, particularly of the ankle; contracture in plantar flexion; extreme sensitiveness and pain; two fistulas on the inner side, and one fistula, one inch in diameter, on the outer; large abscess on the dorsum pedis; profuse suppuration; high temperature; severe septic stage; patient emaciated. An ablation had been considered. Soon after the beginning of milt diet, there was a marked change in condition,—normal temperature, lessening of the pain and secretion, improvement of the appetite. Five months later the patient had gained fifteen kilograms (thirty-three pounds). Seven months after the beginning of the treatment the patient was discharged, practically cured. Today, he is riding a bicycle, using the leg.

CASE 2. C. W., seventy-one years old (Figs. 4 and 5). Ill two years. Diagnosis: Tuberculosis of the knee joint. Four fistulas on the two sides of the patella, with profuse discharge. Flexion contracture of the joint (about one hundred degrees). Patient

very cachectic; impossible for him to walk, even with crutches. Three months after beginning the milt diet the swelling of the joint disappeared, the fistulas closed; no pain; good general condition; improvement of motion of the joint. Now the patient can walk with a stick one or two hours, and without any pain. This case of a patient of seventy-one emphasizes the value of this treatment, for the difficulty of cure of senile tuberculosis is well known.

CASE 3. J. M., six years old (Figs. 6, 7, and 8), ill one and one-half years. Diagnosis: severe tuberculous coxitis; five fistulas, with profuse discharge. At the time of admission the child appeared moribund. The left hip showed a contracture in flexion and adduction; the abdomen was meteoristic, rigid (tuberculous peritonitis), eyes were oedematous, with eczema of the lids; oliguria was present, the urinary sediment showing blood leucocytes, kidney epithelium, and casts. Soon after the beginning of the milt administration, rapid improvement in the general condition of the patient was evident. Five months later the fistulas had closed; there were no peritoneal symptoms; the urine had cleared. The child had gained more than ten kilograms; and was discharged with an orthopaedic apparatus.

SUMMARY

1. The spleen has a markedly beneficial influence on tuberculosis by producing antibodies and increasing the resistance of the diseased tissue.

2. The calf spleen appears to exert a decided influence upon human tuberculosis.

3. The active substance of the spleen is not as yet known. Therefore, the calf milt is given either raw or rare, in order not to destroy the active substance.

4. The course consists of daily doses of fifty to one hundred grams for four weeks, followed by intermission of two weeks. It may be necessary to repeat this administration several times.

5. The improvement in a great number of cases is striking, especially the improvement of the general condition.

6. The milt diet is harmless and should be tried in all severe cases.

REFERENCES

BAYLE: L'Opothérapie Splénique. Presse Méd., XXXIII, 1267, Sept. 23, 1925.

ELIOT, E.: Subcutaneous Rupture of the Spleen. New York Med. J., LXXXVI, 49, 1907.

HARROWER, H. R.: The Therapeutic Action of Splenic Extract and its Application in the Treatment of Tuberculosis. Lancet, I, 524, 1913.

HUTTER, F.: Milztherapie bei Kehlkopftuberkulose. Wiener klin. Wchnschr., XLII, 1531, Nov. 28, 1929.

LOEFFLER, F.: Milzverfütterung bei eitrigen Knochen- und Gelenkerkrankungen. Zentralbl. f. Chir., LVI, 2946, 1929.

MENDEL, F.: Thymusdrüse und Rachitis. Münchener med. Wchnschr., XLIX, 134, 1902.

MEYER, A.: Beitrag zur Kenntnis der Milzfunktion. Centralbl. f. d. Grenzgeb. d. Med. u. Chir., XVIII, 41, 1915.

NOETZEL, W.: Über Milzexstirpation wegen Milzverletzung. Bruns' Beitr. z. klin. Chir., XLVIII, 309, 1906.

RUTTGERS, P. und KAMSLER, A.: Über Milzdiät bei Tuberkulösen. Brauer's Beitr. z. Klinik d. Tuberkulose, LXXII, 68, 1929.

SCHRÖDER, G.: Über Tuberkulinbehandlung. Brauer's Beitr. z. Klinik d. Tuberkulose, XIV, 359, 1909.

FLIEGEL, O.: Milzverfütterung bei Gelenktuberkulose. Deutsche med. Wchnschr., LIV, 2053, 1928.

ROENTGEN DIAGNOSIS OF BONE TUMORS

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The purpose of this communication is to review briefly the subject of bone tumors, particularly from the viewpoint of the roentgenologist.

The confusion that has existed heretofore in the diagnosis of bone tumors was in part attributable to the lack of a comprehensive classification. This problem was somewhat simplified by the excellent work of the Codman registry, which made roentgen diagnosis a much more satisfactory procedure. The diagnosis of bone tumors in general is not a simple matter for the roentgenologist. The various and diverse changes any bone tumor may produce are many, and experience has taught the careful roentgenologist to be extremely cautious in his interpretations. Even with what appears to be a characteristic tumor one often meets with surprising refutation in the operating room or on microscopic examination of the specimen.

The x-ray film might seem so obvious a representation as to be evidence, sufficient in itself, of the particular type of pathologic process it represents; but experience proves this to be a fallacy. While at times a particular tumor may fall into a particular category, it is nevertheless true that many do not, and corroborative, collateral evidence is essential to a diagnosis. The course and progress of the case and one constant—time—may actually be the only means upon which the final opinion may be based.

In considering bone tumors one must in general remember the changes in osseous structures, the result of an inflammatory lesion, as typified in osteomyelitis. Most of the changes seen in osteomyelitis are encountered in bone tumors and the differential diagnosis may be extremely difficult. The specific variation will be sufficiently stressed.

Infectious inflammatory lesions in bone may occur either in the medulla, cortex, or periosteum, usually however in the medulla. For our purpose then, let us consider what occurs.

The most important change is destruction involving the medulla, perhaps even the cortex, and extending for a variable distance along the shaft. This is usually noted as a local area of osteoporosis or cancellous destruction involving the bone, usually at the site of the nutrient vessel supplying the segment. The size of the destroyed area will of course vary with the size of the vascular channel involved. If the main nutrient vessel is involved, the entire shaft may be destroyed. If a small terminal vessel is occluded, a small localized area of necrosis (abscess) may be noted. The infection may then spread by means of the haversian canals to contiguous sections of bone, at times leaving between it areas of normal uninvolved tissue. It is possible at this stage to have multiple areas of destruction

present. The pus may burrow through the canals, devitalizing the tissue and completely separating small segments of bone sequestra. If the infection occurs beneath the periosteum, it may burrow up and down this sheath underneath, elevating it. There is then an extensive periostitis produced. The cortex may or may not be involved. If it is, we have an osteoperiostitis. Occasionally the infection becomes fairly well walled off and a localized subperiosteal abscess results. The new bone is deposited in such a manner that it may materially increase the diameter of the shaft, and it is important for our study to recall that the increase in the caliber of the bone thus produced is due to new bone deposit, and not to expansion. There is, however, retention of the general contour of the shaft. In chronic cases reactive manifestations occur. These take the form of osteosclerosis, cortical thickening, or periosteal proliferations, usually combined to a variable degree. In the small bone abscess, a dense sclerotic wall or barrier may be produced, or as sometimes happens, the earliest indication of a cortical abscess may be the slight periosteal reaction. The periostitis is usually rough and irregular, the bone being deposited in layers parallel to the long axis of the shaft. If the destroyed area involves the ends of long bones, direct extension into the joint and into all the bones of the joint may occur.

All the changes described may occur as single or multiple lesions involving the same bone and combined to a variable degree.

To summarize, we have the following processes in osteomyelitis:—

1. Areas of bone destruction varying in size from the small abscess to massive involvement of a segment of bone. Predominating destruction parallel to the long diameter of the shaft. Areas of destruction alternating with normal bone.

2. Sequestration, commonly present, and rarely seen in tumors.

3. Irregular periostitis parallel to the long axis of the shaft and rarely deposited in layers or spicules perpendicular to the shaft. The one exception is the gumma, which radiographically may show perpendicular bone production. Here, however, the new bone is in intimate contact with the shaft and if the outer ends of the striated areas are closely examined, it will be found that the ends unite producing the "lace-work" periostitis. Examination of the other bones of the skeleton usually reveals other evidence of syphilis.

4. Medullary, cortical, and periosteal sclerosis, combined to a variable degree.

It is important to remember these general characteristics in studying bone tumors. What then are the general features that distinguish benign from malignant tumors?

When we recall that malignant tumors are lawless growths, we can readily see what the general characteristics of a given lesion might be. Involvement of a bone in all directions, particularly transverse to the long diameter of a shaft, is extremely suspicious of malignancy. Putting it in another way, a diffuse, irregular, and extensive growth suggests malignancy.

On the other hand, a localized sharply defined growth with limiting borders and arising from a single point of origin would suggest a benign lesion. Involvement of the soft parts, particularly bone production in the soft parts, and transverse to the long diameter of the shaft, especially if associated with medullary involvement, suggests malignancy. In general we may say that simultaneous involvement of the medulla, cortex, and soft parts means malignancy and that definite demarcation, limiting border, and single point of origin indicate a benign tumor. Bone expansion occurs in either benign or malignant tumors, but it is usually greater in benign tumors. Many writers have considered perforation of the cortex a pathognomonic sign of malignancy, but this view is fallacious as my series of bone tumors include a few benign types wherein perforation of the cortex had occurred. Lesions involving more than one bone may be either neoplastic or inflammatory,—in children usually inflammatory; and in adults frequently malignant. Medullary growths in the small bones of the hands and feet are either cysts or enchondromas and occur at all ages. Primary malignancy is rare in the small bones of the hands and feet. In the young, medullary tumors involving the ends of long bones and associated with fractures are usually cysts; whereas, medullary growths in adults associated with fractures are either metastatic malignancy or myelomas, occasionally giant-cell tumors. Finally, the presence of sequestra practically always indicates a benign lesion. Occasionally it is hard to determine whether a segment of bone in the soft tissues is a sequestrum or bone production in the soft parts, as is sometimes seen about the larger joints, particularly the hip. Here an atypical pyarthrosis, burrowing under the acetabular shelf, may separate this segment and the appearance then closely similates an endothelioma. I have such cases on record. But there is here usually other evidence of the true character of the lesion, — such as involvement of the joint surface, concomitant involvement of multiple bones of the joint, periostitis, or secondary subluxation of the head of the femur.

We may summarize, then, the following points in the differential diagnosis:—

General Characteristics of Bone Lesions

Osteomyelitis	*Benign Tumors*	*Malignant Tumors*
Single or multiple.	Localized as a rule.	Single or multiple.
Sharp or irregular border.	Sharp limiting border.	Irregular invasion.
Involvement of medulla, cortex, or periosteum, or combined.	Limitation to either medulla, cortex, or periosteum.	Involvement of cortex, medulla, and periosteum simultaneously.
No bone expansion.	Bone expansion great.	Bone expansion slight.
Destruction solely within bone.	Tumor within bone, except cortical group.	Tumor in and about bone.
Osteoblastic and osteoclastic within lesion.	Either osteoblastic or osteoclastic.	Osteoblastic or osteoclastic within same tumor.
No soft-tissue involvement.	No soft-tissue involvement.	Soft-tissue involvement.
Periosteal thickening.	No periosteal stripping.	Periosteal stripping.
Parallel bone deposit.	Parallel bone deposit in pseudoneoplastic group.	Perpendicular bone deposit.
Slow development.	Slow development.	Rapid development.

The matter of classification of bone tumors is extremely difficult, since all classifications are subject to exceptions; but in a general way one must at least have a working formula. What we employ is one that has met our needs. This does not by any means infer that it is the only formula or classification possible. It is presented in the hope that it may be of some value in clarifying the problem.

CLASSIFICATION OF BONE TUMORS

- BENIGN
  - 1. *Cortical—osteoblastic*
    - *a.* Osteoma
    - *b.* Osteochondroma
    - *c.* Exostosis
    - *d.* Pseudoneoplastic
  - 2. *Medullary—osteoclastic*
    - *a.* Enchondroma
    - *b.* Giant-cell tumor
    - *c.* Cyst
    - *d.* Osteitis fibrosa cystica
- MALIGNANT
  - 1. *Primary*
    - *a.* Osteogenic . . .
      1. Medullary and Subperiosteal
      2. Telangiectatic
      3. Sclerosing
      4. Periosteal
      5. Fibrosarcoma—Medullary and periosteal
      6. Parosteal—Capsular
    - *b.* Ewing Tumor
    - *c.* Multiple Myeloma
    - *d.* Unusual Types
  - 2. *Metastatic—osteoclastic and osteoblastic*
    - *a.* Prostate
    - *b.* Breast
    - *c.* Thyroid
    - *d.* Kidney
    - *e.* Lung

FIG. 1

Osteoma of a metacarpal bone. Cortical tumor consisting of normal bone constituents.

BENIGN TUMORS

1. *Cortical Group*

   a. Osteomas
   b. Osteochondromas
   c. Exostoses
   d. Pseudoneoplastic

These are all benign osteogenic tumors. They all arise from the cortex in the form of a pedicle and extend into the soft parts. They are sharp, well defined growths. The medulla is uninvolved and there is no cortical or periosteal reaction. Although benign they are prone to recur if incompletely removed.

FIG. 2

Osteochondroma of the femur. Note elongated metaphysis and multiple cauliflower-like growths. This case may be included with the dyschondroplasias. (See Jansen, Murk: Dissociation of Bone Growth. Robert Jones Birthday Vol. Oxford Press, 1928).

a. The osteomas are tumors with a broad base containing cancellous structure and covered with cortex and periosteum. In other words their structure is identical with that of the bone from which they arise. They may occur in any bone, but they are most frequent in the humerus, femur, and tibia (Fig. 1).

b. The osteochondromas are typically "cauliflower-like growths", having a thin pedicle and extending into the soft tissues. They are bony at the base and cartilaginous at their extremities. They are commonly found in the long bones, particularly the tibia, femur, and fibula. In the lower end of the tibia they produce contour deformities of the fibula and in the lower ends of the radius and ulna they may involve the epiphyses; delayed development of the bones results, and it is in the investigation of the resultant deformity that the true lesion is discovered. They are often referred to as "osteochondromatosis" (Fig. 2).

c. The exostoses are multiple small excrescences. They occur near the epiphyseal line, pointing away from the contiguous joint. These very characteristics distinguish them from malignant lesions. The commonest

FIG. 3

Multiple exostosis of the femur and tibia. Stalagmite and stalactite tumors, pointing away from epiphyseal lines.

FIG. 4

Calcified hematoma of the thigh. Dense circumscribed tumor in the soft tissues, detached from bone. Periostitis of the outer surface, middle third of the femur.

involvement is in the ends of the tibia, femur, and fibula; projecting as stalagmites from the lower ends and as stalactites from the upper ends of the shafts. As a rule their extreme tips are narrower than their bases in contradistinction to the osteomas which are usually broadest at their tips. It would be best to include this group with the preceding as one classification under the designation of "multiple cartilaginous exostosis" since they have an identical origin and similar structure (Fig. 3).

d. Under this group must be included calcified hematomas. These are localized calcific deposits either in the soft parts or else beneath the periosteum, depending on the site of the original hemorrhage. They undergo calcification in layers parallel to the long axis of the shaft, but not invariably so, since irregular circular or ovoid areas of calcification may occur in the soft parts. The subperiosteal hematomas are usually seen after injury or in the hemorrhagic diatheses,—as scurvy, purpura, or hemophilia. The periosteum is elevated and becomes calcified. In scurvy one often sees the original shaft completely surrounded by new bone. This condition could be mistaken for a tumor, but the age of the patient and the multiplicity of the lesions, together with the history and physical examination, sufficiently identify them. In the traumatic type, the calcification may occur in the soft parts and stereoscopic plates will show the deposit in the soft parts and in no way an integral part of the shaft. In neither case is the medulla involved (Fig. 4).

Myositis ossificans should be included with the pseudoneoplastic group. This is a degenerative calcific lesion. It may be general or local, usually however local, and is due to rupture of muscle fibers or periosteum. In the generalized form large groups of muscle fibers are affected, occasion-

FIG. 5

Myositis ossificans. Irregular calcific deposits in the soft tissues of the thorax and proximal ends of the humeri. Osseous structures intact.

ally almost the entire muscular system, and fixation of the body results (mummification). In the traumatic type only a small muscle bundle is involved and this manifests itself as a localized calcification in the soft parts, external to the shaft and deposited in the long axis of the muscle fibers. No cortical, periosteal, or medullary reaction occurs. And when it is recalled that benign or malignant bone tumors usually involve either the medulla or cortex it will readily be seen that this condition presents no unusual diagnostic problem (Fig. 5).

Ossifying periostitis will occasionally be mistaken for a neoplasm. Its name sufficiently designates it. It may be either traumatic

FIG. 6

Ossifying periostitis of the femur. Progressive bone deposits on the anterior surface of the femur. No cortical or medullary involvement.

FIG. 7

Enchondroma of the proximal phalanx of the fifth finger. Sharply defined, medullary tumor with pathologic fracture. Note absence of trabeculation or soft-tissue involvement.

or infectious and presents none of the radiographic criteria previously given for neoplasms. It is slow-growing and not accompanied by any of the clinical evidences of a malignant tumor. Frequent radiographs will demonstrate the benign character of the lesion (Fig. 6).

The second important class of benign lesions are the central tumors. These may be grouped as follows:—

2. *Medullary group*

a. Enchondromas
b. Giant-cell tumors
c. Cysts
d. Osteitis fibrosa cystica

a. Enchondromas: These are central cartilaginous tumors often seen in the small bones of the hands and feet. They may be either single or multiple, varying in size from minute lesions to masses involving the entire substance of the shaft. They may expand the bone, erode the cortex, and pathologic fractures result on slight trauma. In the shafts of long bones, they may produce large tumors of the expansile type, often resembling the giant-cell tumors. At times they may degenerate to form chondrosarcomas (Fig. 7).

b. Giant-cell tumors: These are extremely important tumors seen in adults, between the ages of twenty and thirty, and involving particularly the ends of bones. They are most frequent in the lower end of the femur; the upper end of the tibia, humerus, and fibula; and the lower end of the radius. Occasionally they may be seen in the pelvis and transverse processes of the spinal segments. They are expansile, trabeculated, "soap-bubble" growths, extending to the cartilage of joint surfaces, but destroying it only by pressure. They grow slowly, but the erosion of the bone may be so great as to result in pathologic fractures. The cortex of the bone becomes thinned out and sometimes perforated. A slight periosteal reaction may be induced. There is no bone production either in the tumor or in the soft parts. A medullary, cystic, expansile, and trabeculated growth, occurring in the condyles of a long bone in adults, is almost invariably a giant-cell tumor. It is sometimes difficult to distinguish between a cyst and a giant-cell tumor, but as a rule the cyst occurs in children up to the age of eighteen and the giant-cell tumor after the age of twenty. While osteogenic sarcoma involves the ends of long bones, it does not as a rule invade the condyles.

Since the earliest description of this tumor, it has been fairly universally accepted as a class of benign central neoplasm of bone,—this despite the fact that many of those originally reported subsequently died of metastasis. However, the impression is fairly prevalent that this is a benign tumor although prone to recur locally if inadequately treated. For that reason it was considered advisable to rename it; thus the term "giant-cell tumor" was suggested instead of "giant-cell sarcoma", since the implication of the term "sarcoma" is that it is a malignant tumor. There is still some controversy regarding the question of metastasis in these tumors. That local recurrence is common is unquestioned, but that distant metastasis may occur is not unqualifiedly accepted. Considering the evidence advanced, it seems obvious from a perusal of the literature that giant-cell tumors may metastasize and kill by metastasis. It would behoove many of us who have treated this type of neoplasm to follow our cases for a period of years in order to establish the subsequent history of those discharged as

cured. That many cases are cured by operation or radiation or a combination of both cannot be denied, but that many are not cured by no matter what procedure is equally obvious. Are we to explain the variable response to treatment to a malignant or non-malignant type of the tumor? Or further, that the results obtained by identical methods are due to the fact that we are dealing with tumors belonging to the same family, of a similar morphology, but differing only in their virulence? In that event we might retain both names,—the "giant-cell tumor" for the benign form, and the "giant-cell sarcoma" for the malignant type. It would then be possible to systematize the methods of treatment, reserving for surgery or radiation their proper places in the therapeutics of this neoplasm. That there is this difference in virulency seems evident when we consider the incidence of unsatisfactory results obtained in the treatment of giant-cell tumors of the femur. What determines the virulency of tumors at this site? Does the mechanical theory explain the whole story, or is it a difference in the biology of the tumor?

The question of the surgical conduct of these cases has been intensively studied during the past few years and the methods of treatment have almost become standardized. While this problem is hardly within the scope of this paper, it seems advisable to mention this aspect of the situation here. We must remember at the onset that there is always a twenty to twenty-five per cent. factor of error in the diagnosis of all bone tumors, but probably less in the giant-cell variety. The method of attack, therefore, must take into account this possibility and must be so elastic as to permit of radical departure from a given plan of treatment. Irradiation is the method of choice and is fairly universally employed. Its advantages are obvious. The tumor is not cut into and there is no danger of metastasis, infection, or hemorrhage. Since the tumor occurs in the proximity of joints, radiation minimizes the resultant deformity. If radiation is ineffectual, surgical intervention may be indicated. The tumor can then be inspected, its character determined, and the surgical indications executed. In this case the ideal treatment is thorough curettage, swabbing the cavity with carbolic acid or zinc chlorid, followed by postoperative radiation and Coley serum (Fig. 8).

c. Cysts: The question of the pathogenisis of bone cysts has been studied during the past few years, and their relationship to the malacic group sufficiently stressed. That this relationship is not casuistic seems to be well established. Their origin appears to be dependent upon a hemorrhage into the bone cavity and it is probably true that in the young bleeding into an elastic distensible medulla permits of the formation of these cysts; whereas in adults the unyielding, inelastic medulla prevents their formation. On the other hand it seems quite conceivable that the process in adults would favor the formation of giant-cell tumors in parts of bone relatively soft,—such as in spongy condyles of the long bones.

The solitary cyst usually occurs in normally constituted bone, whereas the multiple cysts occur in the malacic group such as in osteomalacia, and

osteitis fibrosa. Very often these cysts are accidently discovered in routine x-ray examinations or on radiographic investigation following trauma. It is probable that many of them exist without arousing suspicion. In the young they are the commonest cause of pathologic fractures.

They may be seen in practically any bone but are commonest, however, in the proximal ends of the humerus and tibia. They extend in all directions, but chiefly along the lines of least resistance, up and down the shaft for a variable distance up to the epiphyseal line. The solitary cyst

FIG. 8

Giant-cell tumor of the radius. Expansile, trabeculated, medullary tumor. Note absence of soft-tissue involvement.

is usually ovoid or circular, exhibiting a dense or thickened limiting margin or border. The transition between normal and pathologic bone is abrupt. The interior of the tumor is usually of homogeneous structure, but may contain a few septa due to residual bone trabeculae. Often these septa are numerous and give the tumor a honeycombed appearance. Bone expansion occurs, and as a result the cortex is thinned out but not perforated in uncomplicated cases. In the malacic group perforation may occur. Pathologic fractures are frequent and may be the first indication of the underlying condition. Curiously enough the fracture, if it occurs in the humerus, may often be noted on the inner surface of the bone apparently remote from the site of the direct trauma. Fractures, either traumatic or surgically produced, are beneficial since they tend to heal the lesion. The

FIG. 9

Solitary cyst of the humerus. Note slight bone expansion, trabeculation, and proximity to epiphyseal line with no involvement of the epiphysis.

line of calcium deposit through the cyst along the line of the fracture may be demonstrated for months after the original injury and gradually the entire cyst fills up with new bone. It is probable that spontaneous healing occurs in many unsuspected lesions of this type (Fig. 9).

d. Osteitis fibrosa cystica: It is debatable if osteitis fibrosa should be included in any classification of bone tumors. By some it has been included with the malacic group, together with Paget's disease. There is much to be said for either view. From the standpoint of the roentgenologist, it cannot be excluded in any discussion of bone tumors. In order to segregate it in the neoplastic group, one would have to discount the associated osseous changes; whereas, to classify it strictly with the malacic group, would necessitate disregarding entirely the occurrence of cysts. On the whole it seems advisable to recognize it as a borderline group. Essentially it is a chronic benign lesion of bone showing general alterations. It may occur as a localized lesion or as the generalized type (von Recklinghausen's). Osteitis deformans (Paget's) also occurs as a local or general disease. Localized osteitis fibrosa occurs at any age; the generalized form occurs in the young, and Paget's occurs in the old, although it is conceivable that the early manifestations of Paget's may be demonstrated in the young.

The changes may be single or multiple in the same bone or in multiple bones. The cancellous structure of the medulla loses its detail and there is bone atrophy present. The medullary cavity increases in width and the bone becomes expanded. The cortex becomes eroded and the periosteum is uninvolved. The demarcation between the cortex and medulla disappears. No changes occur in the soft tissues. In the skull there is thinning and decalcification of the bone, resulting in asymmetry. As a result of the softening, bowing deformities are common and fractures frequent. Scattered throughout the pathologic bone may be vacuolated areas of small isolated cysts varying in size and shape. This cyst formation is at times very extensive. The margins of these cysts may show some reactive manifestations characterized chiefly by thickening of the lining membrane, or else complete reossification. Longitudinal striations may occur through the involved area (Ollier's disease) or punctate hypercalcification (generalized condensing osteitis). Is it possible that the changes described apply to the active stage of the disease and that the hyperostosis of Paget's is nature's regenerative effort directed to reinforcing a weakened skeletal system by replacing the deficient calcium proportion of the bone? Between the malacic and hyperostotic stages many gradations are possible. Often the disease remains quiescent for years without any regenerative effort. In Paget's there is the above described metamorphosis, and it differs from osteitis fibrosa only in the hyperostosis. As is common in many bone lesions, nature's reparative effort is overdone. There results then marked eburnation, chiefly in the skull, pelvis, and long bones. The most typical changes in von Recklinghausen's disease are in the long bones, whereas, in Paget's disease the skull bones show the most characteristic changes (Fig. 10).

MALIGNANT TUMORS

1. *Primary Group*—The tumors of this group are important because of their frequency and because of the clinical problem they present. The first large group may be classified as follows (Ewing):

a. Osteogenic Tumors
1. Medullary and subperiosteal
2. Telangiectatic
3. Sclerosing
4. Periosteal
5. Fibrosarcoma—Medullary and periosteal
6. Parosteal—Capsular

1. Osteogenic sarcomas are malignant tumors derived from bone-forming elements. These tumors occur at any age, most commonly, however, in young adults between the ages of eleven and thirty. Their point of origin is somewhat debatable. This group is often classified as medullary, subperiosteal, or periosteal. This group presents an extremely difficult task radiographically, since it is almost always impossible to determine the point of origin of the neoplasm. It may be best perhaps for our purpose to call this entire group "osteogenic sarcoma", recognizing that they arise from the medulla, cortex, or periosteum and that the tumor may show predominating sclerosis or vascularization. They occur most commonly at the ends of the shaft. From their point of origin they grow in all directions, irregularly destroying the bone, perforating the cortex, and extending into the soft parts. In the osteolytic type, however, destructive changes solely may predominate, and in the osteoblastic or osteogenetic type, new bone may be produced in the soft tissues. In this instance the original shaft may be seen through the mass, and this point is of extreme importance in the diagnosis. It should be recalled that the benign lesions usually begin in the shaft and destroy as they expand. In the osteogenic variety, however, simultaneous involvement occurs in the medulla and soft parts, so that the tumor grows in a "cuff-like" shape about the bone. In the later stages the entire shaft may be destroyed and fractures and bizarre dislocations result. There may be produced transverse bony spicules in the soft parts, the outer ends of which are ununited. The transverse striations usually extend almost to the periosteum. The periosteum distant to the lesion may be stripped off, due to infiltration of the cells. In inflammatory lesions the periosteum is involved immediately about or distant to the infection, but is not peeled away from the bone proper.

2. The telangiectatic tumor gives the appearance of a rapidly spreading osteolytic process which may even invade the epiphyses. The shaft becomes destroyed and the periosteum elevated. The zone of invasion usually is sharply defined and the tumor may even resemble the giant-cell variety. This type is extremely malignant, metastasizing in a few months.

3. At times the entire bone is converted into an eburnated mass and the medullary cavity completely replaced by this dense tissue. In the

FIG. 10

Localized osteitis fibrosa of the femur. Note bone expansion, cystic changes, and bowing deformity with no soft-tissue changes.

FIG. 11

Sclerosing osteogenic sarcoma of the tibia. Dense circumferential "cuff-like" bone production. Note bone production in the soft parts.

FIG. 12

Periosteal osteogenic sarcoma of the femur. Note cortical and periosteal reactions with perpendicular bone production in the soft tissues.

early stage there may be nothing but an osteitis associated with a slight periosteal reaction, simulating the sclerosing osteomyelitis of Garrè. The later stages, however, reveal the typical "cuff-like" sclerosing tumor (Fig. 11).

4. The term "periosteal sarcoma" is frequently employed by roentgenologists and is a roentgenologic rather than a pathologic classification. It simply means that the tumor is more periosteal than medullary. This neoplasm arises from the outer layers of the periosteum, extends laterally, and encircles the shaft, and may produce contour deformities. The new bone produced in the soft tissues assumes a "flakey" appearance. Perhaps this term is a good one to retain for reeducation purposes. It is now grouped with the extraperiosteal sarcomas (Fig. 12).

5. The fibrosarcomas may be either medullary or periosteal. These are relatively benign osteogenic tumors. They may be seen as sharply defined medullary tumors occurring in the ends of long bones. They are expansile and osteolytic and may perforate the cortex and periosteum and extend as a firm mass into the soft tissues. The periosteal type extends outward as an opaque mass from the periosteum. As a rule it does not destroy the shaft (Fig. 13).

FIG. 13

Fibrosarcoma of the hand. Note cortical defect in the shaft of the third metacarpal bone.

6. The parosteal and capsular sarcomas usually appear before the age of thirty, and arise from the capsules or soft tissues about the joint or from the tendon sheath. They are common in the knee joint and do not invade bone. Since they produce no constant roentgenographic appearance, they are often erroneously diagnosed on x-ray examination and are

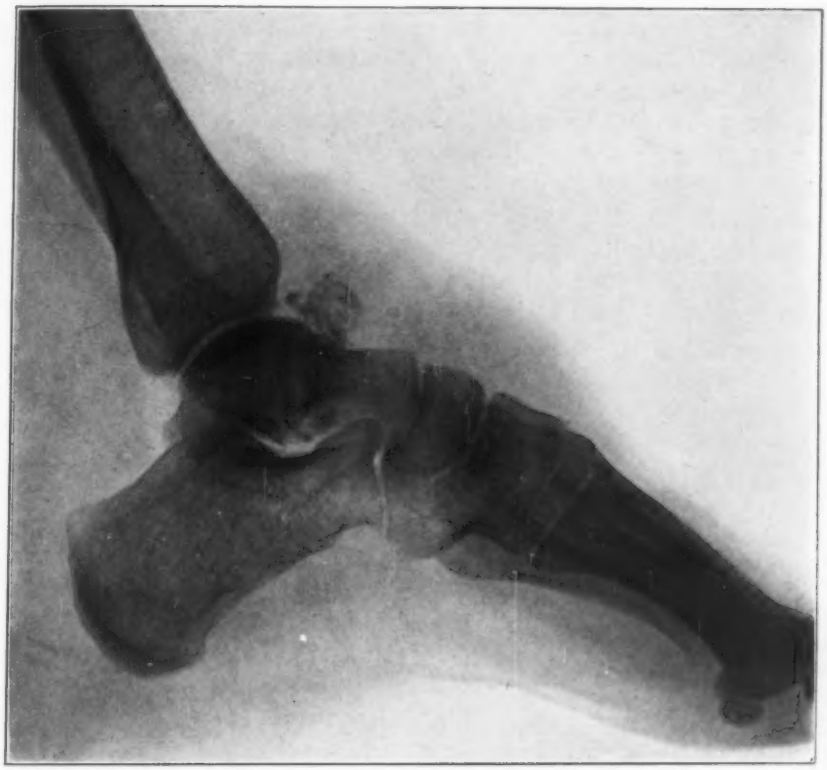

FIG. 14

Capsular sarcoma of the foot. Note soft-tissue swelling. The calcific deposit may be the result of previous injury.

discovered on examination of the microscopic section (Fig. 14).

It is extremely important to x-ray the lungs and skull in all suspected cases of these types, since metastatic lesions may be present when the patient is first seen. The futility of local radical excision or amputation in such an event is obvious. These conditions must be differentiated from the low-grade inflammatory bone lesions, since the surgical indications and procedures are so different.

Luetic osteitis or the gumma may resemble sarcoma. We have a case of this type. A lesion of the upper end of the tibia, in a girl of nineteen, was diagnosed by capable roentgenologists as an osteogenic sarcoma. Blood examination revealed a four plus Wassermann. Under salvarsan treatment the lesion rapidly retrogressed and this patient is alive and well today, four years later. Unfortunately syphilis of the osseous system frequently gives a negative Wassermann. It is important to remember that all patients with periosteal tumors should have the benefit of a Wassermann and even a therapeutic test. As a rule luetic bone lesions are multiple and may show generalized cortical or periosteal thickening which

may or may not be associated with deformities (saber-tibia). The cortical and periosteal reaction in syphilis is greater than in sarcoma.

The sclerosing osteogenic sarcoma may resemble osteomyelitis but with one important difference. The new bone produced in osteomyelitis is an integral part of the shaft, whereas in sarcoma it is produced in the soft tissues about the bone, often in the form of a cuff. The bone produced in osteomyelitis is laid down in layers parallel to the long axis of the shaft, whereas, in sarcoma it is perpendicular to the long axis of the shaft. In the osteoclastic types of malignancy the differential points are similar to those described for the Ewing tumor, excepting of course that the osteogenic variety occurs at the ends of bones.

The generalized type of Paget's need not here be considered. The localized or single manifestation of this condition may resemble osteogenic sarcoma, particularly the sclerosing type, and a biopsy may be necessary to establish the diagnosis. I know of no infallable roentgen method to differentiate them. Paget's is common after fifty years of age, somewhat beyond the common age for osteogenic sarcoma. Occasionally Paget's is combined with bone sarcoma and even with metastatic malignancy.

b. Ewing tumors: Histologically these tumors should be and are classified with the myelomas. Radiographically, however, they present characteristics totally different from myelomas and are therefore classified separately. Of all the tumors these are most frequently erroneously diagnosed; usually as osteomyelitis. They are extremely common between the ages of eleven and thirty. Although usually seen as a single lesion, multiple primary bone involvement is not infrequent. Any bone may be affected,—most frequently, however, the tibia, fibula, and ulna of the long bones; and the clavicle, ribs, and os calcis of the small bones. The tumor begins in the shaft of the long bones and extends towards the extremities. As it spreads it expands and destroys the bone, usually involving more than one-half of its diameter. The medulla and cortex are destroyed and pathologic fractures may result. There is no sharp demarcation between normal and pathologic bone. The lamellae are separated into pathognomonic "onion-like" layers which occur parallel to the long diameter of the shaft. The periosteum is usually destroyed but it may be elevated or stripped by the infiltration of tumor tissue. Occasionally there may occur an irregular periostitis resembling that seen in osteomyelitis, or else we may have radiating spicules of bone resembling osteogenic sarcoma. Practically no reactive manifestations are present; in other words, the tumor is essentially osteoclastic. Often a soft-tissue mass may be felt about the bone and may even give the impression of fluctuation. Metastasis occurs early and usually to the skull and lungs. A lesion in the long bones in children, simulating osteomyelitis without however the typical symptoms of an osteomyelitis, is extremely suspicious of an endothelioma. A mass about a bone fairly large and slightly tender without fluctuation or constitutional reaction sufficient in degree for the size of the lesion, is suggestive of endothelioma. Be guarded in any atypical osteomyelitis,

particularly where the symptoms recur irregularly with periods of comparative comfort and more particularly if the lesion is associated with an unusual degree of anaemia. Often the symptomatic relief is concomitant with progressive enlargement of the local mass (Fig. 15).

The simultaneous involvement of the cortex, medulla, and periosteum also occurs in osteomyelitis and thus it can be seen how similar the lesions are, radiographically. This situation was emphasized in a recent communication in which I stated, "It is at times almost impossible to differentiate between inflammatory reactions and neoplastic destruction, the proper identification of which often, of itself, classifies the lesion. The inflammatory manifestations in some neoplastic destructions are so combined that we are tempted to believe the neoplastic dénouement an accidental transition from an inflammatory state. This feeling becomes intensified when we consider the local manifestations as well as the constitutional reactions seen in this condition. Local heat, swelling, and pain becoming increasingly intense and, associated with temperature and leucocytosis, all seem to indicate an infectious process. When to this is added a roentgenogram showing bone destruction associated with periosteal reaction, there appears to be sufficient evidence to indicate an infectious process. The sudden acceleration in local growth, often because of accident or operation, seems to be the result of the introduction of certain biologic factors, the nature of which may not be suspected nor their true mechanism understood. We have no adequate scientific proof that an endothelioma supervenes on an osteomyelitic process, nor is this our contention, but the pictures are so similar, radiographically, that one cannot escape the implication, particularly since the same diagnostic limitations hold for the interpretation of microscopic sections."

There are, however, some general differential points. The medullary destruction in osteomyelitis is usually associated with reactive manifestations producing bone sclerosis or eburnation. Multiple patchy areas of destruction associated with sclerosis would indicate an osteomyelitis. There is cortical destruction or "splitting" in endothelioma producing the "onion-like" layers, whereas in osteomyelitis there is cortical thickening. Bone expansion occurs in endothelioma, whereas the increase in the diameter of the bone in osteomyelitis is due to actual new bone production or deposition, as has already been pointed out. The periosteum is irregularly thickened in osteomyelitis, whereas it is either destroyed or peeled away from the bone in endothelioma. Osteomyelitis may occur in any portion of a bone, whereas endothelioma usually occurs in the shaft. Osteomyelitis frequently produces a sinus or sequestrum. This is never seen in endothelioma. In addition to these findings there may occur the usual evidences of malignancy,—metastasis to regional lymph nodes, skull, and lungs. If with all the evidence at hand, a differential diagnosis cannot be made, a therapeutic test may be employed. Radiation of a suspected lesion will produce rapid regression of the lesion if it is an endothelioma and will have practically no effect if it is an osteomyelitis. It seems inadvisable in

FIG. 15

Endothelioma of the humerus. Note medullary and cortical involvement, slight expansion, and tendency to form "onion-like" layers.

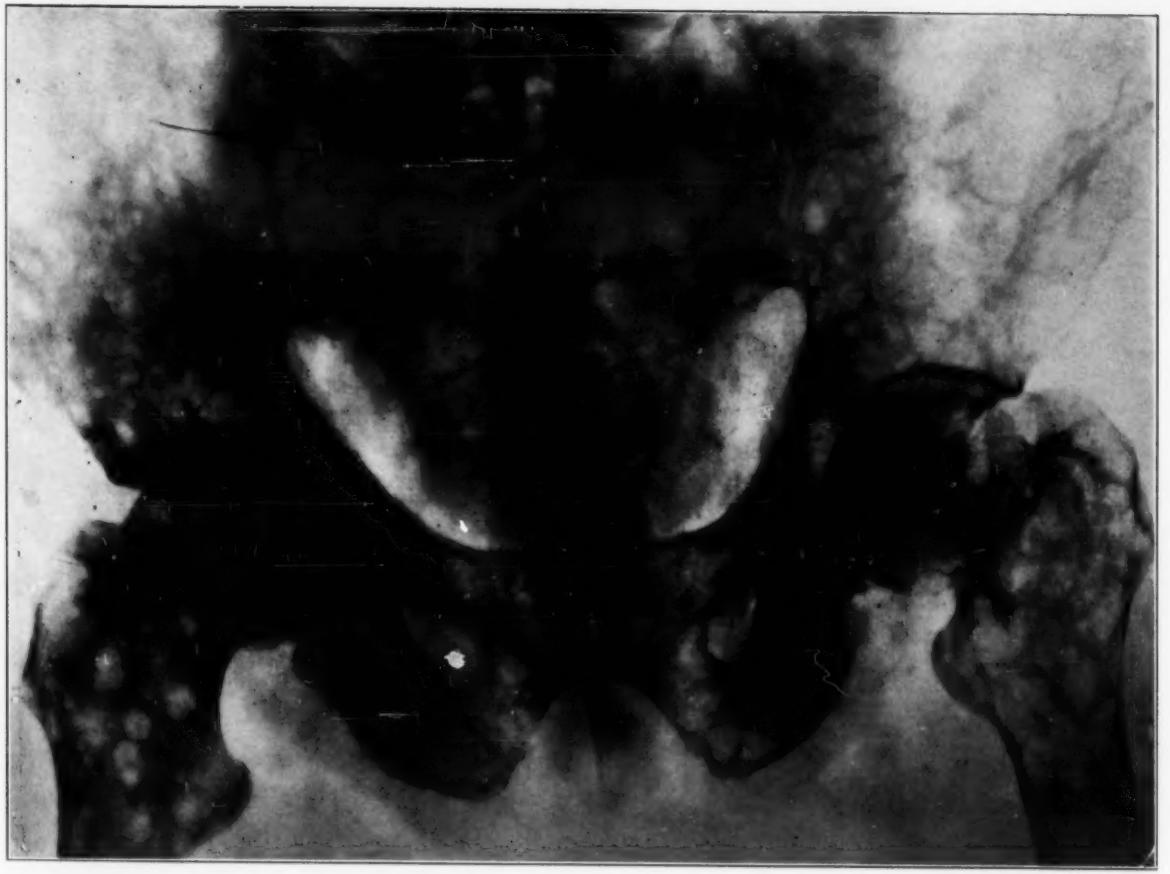

FIG. 16

Multiple myeloma of the pelvis and femora. Note multiplicity and sharp definition of the medullary lesions. No periosteal or soft-tissue changes.

lesions of this type to do a biopsy. We have frequently seen rapid dissemination of the tumor following such procedure. Biopsy with its attendant dangers is unnecessary when a simple therapeutic test is available. We may summarize then the differential features as follows:

Endothelioma	*Osteomyelitis*
1. Usually in young.	1. Any age.
2. Usually single lesion in early stage.	2. Commonly multiple in same bone.
3. Bone expansion present.	3. Increase in caliber due to new bone deposit.
4. Cortical destruction, onion-like layers.	4. Usually cortical thickening or destruction, or both.
5. Periosteum destroyed or stripped.	5. Periosteum irregularly thickened.
6. Medulla destroyed—no sclerosis.	6. Medulla destroyed, sclerosed, or eburnated.
7. No sinus or sequestrum.	7. Sinus or sequestrum, or both.
8. Evidence of metastasis.	8. No metastasis. May be multiple.
9. Response to radiation.	9. No response to radiation.

c. Multiple myelomas: These are multiple malignant tumors of bone which arise from bone marrow and show plasma cells or their derivatives. They occur usually after forty years of age and present a characteristic roentgen appearance. They occur in the ribs, sternum, vertebrae, femur, skull, and pelvis. The medullary cavity shows numerous tumors which expand the cavity, erode and thin out the cortex, but produce no bone regeneration or cortical or periosteal reaction. In the skull and pelvis this punched out appearance is very characteristic. In the spine, collapse of the bodies occurs. In the long bones, pathologic fractures are frequent and often painless. One must remember that a pathologic fracture may also occur in metastatic malignancy. In the presence then of a pathologic fracture these two conditions must be considered,—if the lesion is single it is probably metastatic malignancy; if the lesions are multiple in the same bone it is probably multiple myeloma. Metastasis may occur to the soft parts, but death may supervene without metastasis. In cases of this type the urine contains the Bence-Jones protein, but it should be remembered that this albuminuria also occurs wherever there is rapid breaking down of tissue. The only other lesions that might simulate this condition are either osteomyelitis or metastatic malignancy. In the first instance there are cortical and periosteal changes; and in the second instance, metastatic malignancy is not so multiple in the same bone. In the humerus and femur expansion of the shaft may occur without destruction of the cortex, and in this it resembles the giant-cell tumor, excepting that the giant-cell tumor is never so multiple and rarely occurs in the shaft. The constitutional reaction appears to be greater in metastatic malignancy than in multiple myeloma (Fig. 16).

d. Unusual types: Under this heading would be grouped the tumors that are infrequently encountered and which do not give a characteristic roentgen appearance. In this category belong such neoplasms as the liposarcoma and myxosarcoma. The diagnosis would depend on the examination of the microscopic section (Fig. 17).

cortical involvement, slight expansion, and tendency to form "onion-like" layers.

FIG. 17

Liposarcoma of the ilium resembling low-grade osteomyelitis or bone regeneration in a localized osteitis fibrosa.

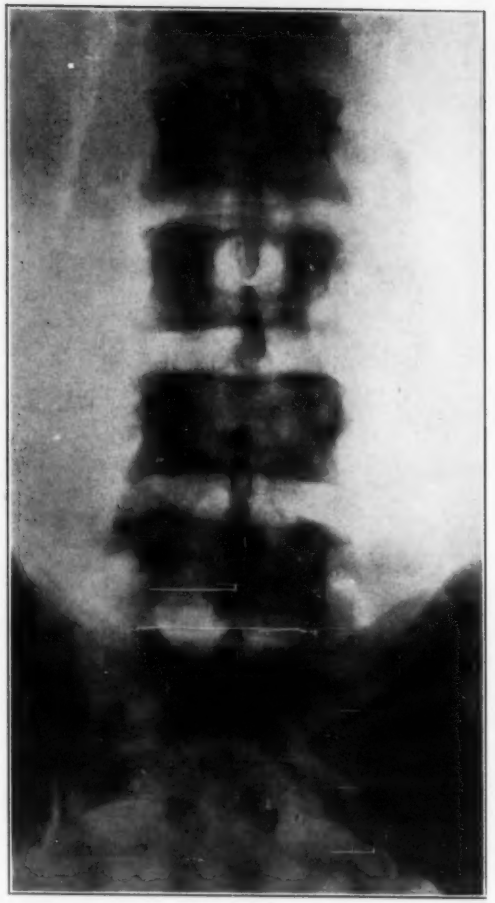

FIG. 18

Metastatic malignancy. Osteoblastic type from carcinoma of the breast. Note diffuse, patchy sclerosis.

FIG. 19

Metastatic malignancy. Hypernephroma of the pelvis, illustrating the "melted-ice" or "ground-glass" type of metastatic lesion.

2. *Metastatic Malignancy:* As the term indicates, these are multiple tumors of bone secondary to neoplastic involvement elsewhere. In men the site of origin is usually the prostate, while in women the sites of origin are either the breast or genital organs. Any bone in the body may be involved, but the spine, pelvis, skull, and ribs most frequently. Metastatic malignancy below the knees and elbows is uncommon. All cases of carcinoma of the breast should have skeletal radiographs prior to operation, since metastasis may already be present. On the other hand it is important to remember that disseminated bone metastasis sometimes occurs which is not demonstrated radiographically or detected on postmortem examination.

a. Prostate; *b.* Breast: Roentgenologically the lesions may be either osteoblastic or osteoclastic, usually combined, but the predominating change usually determines the type.

The osteoblastic lesions are noted as patchy or flakey areas of increased density in the involved bone. In the skull the osteoblastic type may be extremely difficult to differentiate from Paget's disease. In the spine no collapse of the segments occurs. This process is seen in scirrhous tumors of the breast and prostate.

The osteoclastic lesions are areas of multiple bone destruction, showing little if any reactive phenomena. These destroyed areas vary in size from minute perforations to areas the size of a small grape-fruit. These osteoclastic changes result in the adenomatous type of malignancy, either from the breast, prostate, or kidneys. In the skull the perforations are very characteristic. In the spinal segments collapse of the bodies, kyphosis, and paraplegia may result. The cartilage of the joint surfaces of the spinal segments remains, however, intact. In the ribs metastasis may result in collapse of the thoracic wall.

In metastasis to the long bones, the tumors are usually at the site of the nutrient vessel. Medullary expansion results, the cortex is thinned out, and slight trauma may produce a pathologic fracture. Frequently the occurrence of fracture is the first indication of the underlying pathology, the original lesion being symptomless. Healing may follow the fracture, but not infrequently the callus or new bone produced may undergo spontaneous lysis and marked displacement and separation of the fragments result.

Aside from these characteristics of bone destruction and bone production, the metastatic foci may take one of two forms. They may be expansile or purely erosive. The expansile type, particularly of the humerus and femur, could well be mistaken for a giant-cell tumor, were it not for its location in the shaft of the bone, where giant-cell tumors are rare. Because of its appearance, this type of metastasis is often referred to as the "melted-ice" or "ground-glass" lesions (Fig. 18).

c. Thyroid: It has been stated that thyroid metastases occur as frequently as do tumors of the breast or prostate. All types of thyroid tumors may metastasize and early recognition of the lesion is extremely difficult and unfortunately so, since they are somewhat amenable to radia-

tion. They may be encountered in the young and have been reported in a patient thirteen years of age.

The metastatic process is often present when the primary focus is so minute and symptomless as to be unsuspected; or on the other hand the primary lesion may recede while the metastatic focus rapidly progresses. Even on section of a thyroid nodule, its malignant character may not be recognized. In other words, metastasis occurs from a simple adenoma which, although too small to be clinically detected, may be histologically indistinguishable from a malignant tumor. Roentgenologically they are cystic, osteoclastic lesions of the "alveolar" type already referred to. They may involve the greater portion of the wing of the ilium and give the "ground-glass" or "melted-ice" appearance. If single in a bone, they may be mistaken for a giant-cell tumor. One of our patients had a single metastatic focus in the neck of the femur, involving the trochanters. This patient sustained a pathologic fracture and in healing irregular trabeculation was produced within the mass. The lesion *per se* was indistinguishable from a giant-cell tumor. It is claimed that in fifty per cent. of thyroid tumors the lesions are single and consequently some surgeons advocate extirpation of the tumor when it occurs in a favorable site.

d. Kidney: Metastatic hypernephroma presents some of the fractures described for thyroid neoplasms. Osseous metastasis may be present even when the genito-urinary tract is symptomless. These lesions are of the osteoclastic type and often show very extensive destructive changes in the bones, particularly of the pelvis. Sometimes the transverse processes of the vertebrae on the side of the involved kidney show this erosive, destructive process. Our experience has been that the individual metastatic foci in hypernephroma are the largest in size of any of the tumors (Fig. 19).

e. Lung: Metastatic processes from the lung resemble those seen from the thyroid and kidney. The lesions are of the osteoclastic or "melted-ice" type. Sometimes the original focus in the lung is not suspected and is only discovered on investigation of the possible source of a tumor in the long bones, perhaps the site of a pathologic fracture. Roentgenologically the tumor *per se* presents no individual characteristics aside from those already mentioned and the diagnosis depends on information obtained from the general roentgenologic investigation, particularly of the lungs. As already stated, roentgenograms of the lungs in any case of suspected malignant tumor, should be a routine procedure in any well conducted laboratory.

FRACTURES OF THE FEMORAL NECK

An End-result Study of Non-operative Treatment

From the Fracture Service of the Massachusetts General Hospital

BY A. W. REGGIO, M.D., F.A.C.S., BOSTON, MASSACHUSETTS

This end-result study of the non-operative treatment of a consecutive series of intracapsular (neck of femur) fractures, is presented with the hope that others may be stimulated to publish their results in a similar, detailed manner. In the literature much information is lacking as regards many important details; hence, such reports of end results are not included here. "Impressions" are not facts, and, therefore, are of no value in a comparative study of end results.

There is such a marked difference in the reported results of the non-operative treatment in these cases, that a careful study of this type of fracture is most illuminating. We have been unable to find in the literature a detailed study similar to the one presented here and the figures given (as found in the literature) are presented for comparison with our own results. It is not perfectly clear that these figures from the literature are strictly for intracapsular fractures only, but a careful attempt has been made to rule out, wherever possible, all figures that could be suspected of not applying strictly to intracapsular cases.

If mistakes have been made in their tabulation, it is due to lack of more definite information in the articles read, as to whether intertrochanteric cases were included or not. These figures make one wonder just exactly how the percentages were arrived at. Are they for all cases, consecutive, just as they came into the hospital without omitting any? That is to say, —was there any selection of cases or were all included, no matter how bad a risk the case was when first seen? Are the unknown results and deaths included or not?

In Table I (the detailed analysis of results from the literature) it seems fairly evident that many of the figures presented need further explanation before they can be accepted at their face value. Of course, all these figures have been given in good faith—that we do not question—but there must be an explanation for such a tremendous discrepancy as seen here.

One possibility is that the standard of classification for "Good," "Bad" and "Fair" is variable. The "Deaths," however, cannot be explained in this way. In this paper our tabulation and classification is based on the following system:—

Good—70 per cent. function or better.
Fair—70–40 per cent. function.
Bad—40 per cent. function or less.
Died—during hospital treatment.

This classification has been adhered to throughout the entire series.

TABLE I

STATISTICS FROM THE LITERATURE

Number Cases	Per cent. Good	Per cent. Fair	Per cent. Bad	Per cent. Died	Per cent. Union	Per cent. Non-union	Per cent. Unknown	Reference
70	90				55			A
172	67.5			6	67.5			B
20	85		5	10				C
14	42.9	36.6	7.1	13.4				D
40	50		25	15			10	E
42				5				F
21	90				76	5		G
29	89		11					H
20	45	15	25	10				I
18	27.7	11.1	27.7	5.5			27.7	J
91	26.4	30.8	42.8					K
112	42			16				L
58	62			29.5				M
25	56			8				N
111	63	30	7					O
70	37.3	11.8	20.3	25.8	49.1	20.4	15.7	P
172	90	36.6	42.8	29.5	76	20.4	27.7	High
14	26.4	11.1	5	5	49.1	5	10	Low
60	58.2	22.5	19	13.1	61.9	12.7	17.8	Average of 903 cases.

Key to references:

A. LÖFBERG, O.: Acta Chir. Scandinavica, LVII, 504, 1924.
B. LÖFBERG, O.: Behandlung der Fractura colli femoris. Zentralbl. f. Chir., LIV, 2222, 1927.
C. MURPHY, E. C. AND DORRANCE, G. M.: Ann. Surg., LXXIII, 752, June 1921.
D. ASHHURST, A. P. C. AND CROSSMAN, E. T.: Arch. Surg., XII, 453, Feb. 1926.
E. MOORE, G. A.: Boston Med. and Surg. J., CLXXXV, 683, Dec. 8, 1921.
F. MOORE, G. A.: Boston Med. and Surg. J., CLXXXV, 688, Dec. 8, 1921.
G. CAMPBELL, W. C.: J. Am. Med. Assn., LXXXI, 1327, Oct. 20, 1923.
H. CAMPBELL, W. C.: Ann. Surg., LXX, 600, Nov. 1919.
I. DORRANCE, G. M. AND MURPHY, E. C.: Pennsylvania Med. J., XXV, 449, Apr. 1922.
J. SEVER, J. W.: Boston Med. and Surg. J., CLXXX, 27, Jan. 9, 1919.
K. British Med. Assn. 1928. Ref. by Mercer: J. Bone and Joint Surg., XI, 303, Apr. 1929.
L. M. N. O. Various references in other articles.
P. Present series from Massachusetts General Hospital, Fracture Service, 1921–1927, reported herewith. (See Table II—Sections 1*A* and 2*A*.)

NOTE—In this table the blank spaces indicate that no figures were given in the articles referred to. The numbers in the line marked "High", indicate the highest figures from *all* the references, not from any one particular article. Conversely, the line marked "Low". The last line shows the *average*, figured from the entire group of 903 cases reported.

TABLE II

END RESULTS IN SERIES 1921–1927

Cases	Cases A. 70	Cases B. 49	Cases C. 21	1. Includes the whole series A. 70	1. B. 49	1. C. 21	2. Omitting unknown cases A. 59	2. B. 43	2. C. 16	3. Omitting dead and unknown A. 41	3. B. 30	3. C. 11
Unknown	11	6	5	15.7%	12.3%	23.8%						
Died	18	13	5	25.8%	26.5%	23.8%	30.6%	30.2%	31.3%			
Good	22	18	4	31.4%	36.7%	19.0%	37.3%	41.9%	25.0%	53.7%	60.0%	36.4%
Fair	7	5	2	10.0%	10.2%	9.6%	11.8%	11.6%	12.6%	17.1%	16.6%	18.3%
Bad	12	7	5	17.1%	14.3%	23.8%	20.3%	16.3%	31.2%	29.3%	23.4%	45.4%
Union	29	24	5	41.4%	49.1%	23.8%	49.1%	55.8%	31.3%	70.7%	80.0%	45.5%
Non-union	12	6	6	17.1%	12.2%	28.6%	20.4%	14.0%	37.4%	29.3%	20.0%	54.5%

A. All types of treatment.
B. Whitman treatment only.
C. Treatment other than Whitman.

How is it possible to have such varying results as shown in Table I?

"Good" results vary from 26.4 per cent. to 90 per cent.; "Bad" results from 5 per cent. to 42.8 per cent.; "Deaths" from 5 per cent. to 29.5 per cent. and "Union" from 49.1 per cent. to 76 per cent.! Possibly a closer analysis of the cases would bring out the answer.

In Table I the liberty has been taken of using "Percentages" instead of "Cases" (in some instances) for the sake of ease and uniformity of comparison, but this does not account for the variations.

By referring to Table II it will be seen how statistics can be made to do gymnastics. For example, the "Good" results can be changed from 19 per cent. to 60 per cent.; the "Bad" from 45.4 per cent. to 14.3 per cent;

TABLE III

TYPES OF TREATMENT

	Cases	Average time maintained	Average stay in Hospital	
Whitman	49	9½ weeks	10 weeks	Total average stay in Hospital 11 weeks
Thomas splint with traction	10	5½ weeks	9 weeks	
Bed only	9	5 weeks	6 weeks	
Plaster spica	2	10½ weeks	15½ weeks	
Whitman, excluding deaths*	36	12 weeks	15 weeks	
Treatment other than Whitman, excluding deaths**	16	6½ weeks	9½ weeks	

*Average duration of treatment before death, 4.7 weeks. (1 day to 16 weeks.)
**Average duration of treatment before death, 4.5 weeks. (4 days to 7 weeks.)

NOTE—Note the difference in the time of treatment and hospital stay, when the cases that died during treatment are omitted. This is particularly striking in the cases treated by the Whitman method. The average duration of life (in those who died during treatment) is about equal for all methods. This is quite instructive.

"Deaths" from 23.8 per cent. to 31.3 per cent.; "Union" from 23.8 per cent. to 80 per cent., and "Non-union" from 12.2 per cent. to 54.2 per cent.

In this table (Table II), under the three columns grouped as *1*, the figures are obviously incorrect, as the unknown cases are included. Unknown results are of no value and therefore have no place in figuring out end results. Under division *2* (Table II) the true answer to the question, "What are the chances of my getting a good leg?" is given, for here the possibility of the patient dying during treatment is still present. However, for finding out what the *actual end results* are, in the patients who survived treatment, division *3* (Table II) gives us the answer.

Attention is also called to the tabulation in this table under the three groups,—that is, "A"—all types of closed treatment; "B"—Whitman method only and "C"—closed methods other than Whitman. This last division is very instructive.

TABLE IV

GENERAL SUMMARY OF

WHITMAN TREATMENT ONLY

Ages	Cases	Died	Good	Fair	Bad	Unknown	Union	Non-union
27–29	M-1	0	0	0	M-1	0	0	M-1
30–39	M-2	0	M-2	0	0	0	M-2	0
40–49	M-1 F-5	0	M-1 F-4	0	0	 F-1	M-1 F-4	0
50–59	M-3 F-10	M-1 F-1	 F-5	 F-1	M-1 F-1	M-1 F-2	 F-6	M-1 F-1
60–69	M-1 F-6	M-1 F-1	 F-3	 0	 F-2	 0	 F-3	 F-2
70–79	M-2 F-16	M-1 F-7	 F-3	M-1 F-2	 F-2	 F-2	M-1 F-6	 F-1
80–83	 F-2	 F-1	 0	 F-1	 0	 0	 F-1	 0
Total cases	M-10 F-39	M-3 F-10	M-3 F-15	M-1 F-4	M-2 F-5	M-1 F-5	M-4 F-20	M-2 F-4
Av'ge ages	M-53 F-64	M-65 F-72	M-39 F-58	M-79 F-72	M-41 F-68	M-53 F-57	M-49 F-62	M-41 F-66

Average age in whole series—59 years.
Average age of Males—52.8 years.
Average age of Females—64.3 years.

TABLE V

GENERAL SUMMARY OF CASES TREATED BY OTHER THAN WHITMAN METHOD

Ages	Cases	Died	Good	Fair	Bad	Unknown	Union	Non-union
20–41	0	0	0	0	0	0	0	0
42–49	F-2	0	F-2	0	0	0	F-2	0
50–59	M-1	0	0	0	0	M-1	0	0
60–69	M-1 F-4	M-1	F-1	F-1	F-1	F-1	F-2	F-1
70–79	M-2 F-5	F-2	M-1	0	M-1 F-2	F-1	M-1	M-1 F-2
80-85	M-2 F-4	F-2	0	M-1	F-1	M-1 F-1	0	M-1 F-1
Totals	M-6 F-15	M-1 F-4	M-1 F-3	M-1 F-1	M-1 F-4	M-2 F-3	M-1 F-4	M-2 F-4
Av'ge ages	M-72 F-70	M-68 F-79	M-71 F-52	M-83 F-65	M-70 F-74	M-70 F-74	M-71 F-56	M-77 F-74

Average age of whole series—71 years.
Average age of Males—72 years.
Average age of Females—70.4 years.

TABLE VI

TYPES OF FRACTURE

Subcapital	15
Central	26
Base	15
Unknown (x-rays lost)	14

(No attempt has been made to say whether a fracture was impacted or not, as the data were not explicit enough to warrant this.)

It is perfectly apparent that the Whitman treatment gave the largest number of "Good" results (60 per cent. as opposed to 36.4 per cent.) and the smallest number of "Bad" results (23.4 per cent. as opposed to 45.4 per cent.). The "Deaths" during treatment and the "Fair" results show less difference (Table II, division *1*, *B* and *C*, and division *3*, *B* and *C*).

In order to bring out the types of non-operative treatment used, Table III is shown.

TABLE VII

CAUSES OF INJURY

1.	Slipped on floor or stubbed toe	20
2.	Fell down stairs or steps	13
3.	Slipped on ice	8
4.	Fell on street	7
5.	Miscellaneous**	6
6.	Tripped over rug	5
7.	Fell out of bed or chair	5
8.	Fell from a height*	4
9.	Hit by automobile	2

**One case each:—

Fell off saw-horse.
Pushed off trolley car.
Hit by bag of cement.
Automobile accident (passenger).
Thrown from wagon in runaway.
Tripped over a ladder.

*One case each:—

Off wharf.
Off fire escape.
Off wood pile.
Out of second story.

Table III explains itself and needs no further comment.

Tables IV and V are necessary for finding out the end results at different ages. The more or less careful or interested perusal of these tables depends on the interest of the reader. It is, of course, evident that "M" stands for male and "F" for female; the figure after each "M" or "F", denoting the number of cases treated at the particular age designated.

Tables VI, VII and VIII are also self-explanatory. It is unfortunate that in Table VI it was necessary to report fourteen cases as having the type of fracture unknown. Owing to a transfer of x-ray plates and films to a new storage vault, or due to the forgetfulness on the part of a borrower, this lack of information cannot be remedied. There was no indication, on the records of these cases, as to the location of the fracture, except that they were intracapsular and not intertrochanteric.

Tables IX and X give the detailed data on those cases in which the patients died during treatment.

The interesting point brought out here is that in determining the type of treatment to be given in a particular case, the poorest risks were treated by some method other than the Whitman, the average age of these patients being seventy-one years; whereas the average age of those treated by the Whitman method was fifty-nine years. This is again reflected in the two tables of the Deaths (Tables IX and X), for we find that among the five deaths which occurred in the cases treated by a method other than the Whitman, the average age was seventy-seven and one-half years; as compared with seventy and one-half years, the average age of those who died during the Whitman treatment.

TABLE VIII

Anaesthesia Employed

Ether	24
None	17
Morphin	9
Morphin and Scopolamin	7
Spinal	7
Gas-oxygen	6
Ethylene	3

TABLE IX

Neck of Femur

Detailed Data on 13 Deaths

By Whitman Treatment Only

Case. Sex. Age.	Year.	Complicating condition on entry.	Duration of treatment.	Anaesthetic.	Cause of death. Hospital stay.
F-77	1921	Old, feeble. Mental.	9 weeks.	Morphin.	Pneumonia—16 weeks.
F-77	1922	Old, feeble.	1 week.	None.	Pneumonia—1 week.
M-58	1922	None.	2½ weeks.	Gas-oxygen.	Embolus—2½ weeks. (Proved at autopsy)
F-76	1923	Mental, cardio-renal. Incontinent.	7 weeks.	Spinal.	Embolus—7 weeks.
F-56	1923	None.	1½ weeks.	Gas-oxygen.	Embolus—1½ weeks.
M-66	1923	Nephritis. Arterio-sclerosis. Myocarditis.	2½ weeks.	Spinal.	Steadily failed. Nephritis. Cardiac—2½ weeks.
F-70	1923	None.	9 weeks.	Ether.	Cerebral Hemorrhage. 10 weeks.
F-72	1923	Arte iosclero-sis. Paralysis agitans.	3 weeks.	Spinal.	Pneumonia—3 weeks.
F-79	1923	Myocarditis. Feeble.	4½ weeks.	Gas-oxygen.	Pneumonia—6 weeks.
F-80	1923	None.	2 days.	Morphin.	Pneumonia—3 days.
F-71	1924	Diabetes.	1½ weeks.	Ether.	Embolus—1½ weeks.
F-61	1924	Mental. Incontinent.	12 weeks.	Morphin.	Embolus—12 weeks.
M-72	1926	None.	1 day.	Ethylene.	Did not regain consciousness and died of oedema of lungs.—1 day.

Average age 70½ years.

TABLE X

NECK OF FEMUR

DETAILED DATA ON 5 DEATHS

DURING TEATMENT BY OTHER THAN THE WHITMAN METHOD

Case. Sex. Age.	Year.	Complicating condition on entry.	Treatment and duration.	Anaesthetic.	Cause of death. Hospital stay.
F-85	1922	Old, feeble.	Bradford frame and sand bags. 3 weeks.	None.	Pneumonia—3 weeks.
F-80	1924	Senile dementia, feeble.	Thomas splint and 15 lbs. traction. 4 days.	None.	Died suddenly. ? embolus—4 days.
M-68	1925	Mental. Irrational.	(1) Cast—ripped off same day. (2) bed only. 6 weeks.	None.	Pneumonia—6 weeks. (Died 36 hours after going home against advice.)
F-75	1926	Mental, bad risk. Cardiac decompensated.	Thomas splint and 15 lbs. traction 7 weeks.	None.	Failed rapidly and died. Cardiac. 7 weeks.
F-79	1927	Very feeble.	(1) Thomas splint 4 days. (2) Up in chair 4 weeks.	None.	Slowly failed and died. 4 weeks.

Average age 77½ years.

In conclusion, it must be clearly understood that this paper in no way attempts to voice any opinion—pro or con—as regards any form of treatment in fractures of the neck of the femur. It is purely an *end-result* study of *consecutive* cases, treated by some closed method. No cases have been omitted, thus avoiding all selection.

The series ends in 1927, as in the latter part of this year, cases for operative treatment began to be selected.

A HISTOLOGICAL STUDY OF THE EARLY PHASES OF BONE REPAIR

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The history of the study of the regeneration of bone is replete with conflicting experimental results. Entirely aside from the merit of various contributions, their very number indicates the complexities of the problem. The earliest point of contention was the theory of the osteogenic power of the periosteum, elaborated by Duhamel and denied by Haller. Since then, both this problem and new ones have been enthusiastically investigated. The use of bone transplants offered both stimulus and complications to the research. Expressions of present-day opinion are varied. For a most interesting and comprehensive review of the earlier literature the reader is referred to the work of Keith.

The present contribution is concerned with the origin, nature, and growth of the cells which repair a fracture, and a study of some of the purely local factors which influence the process. The work was based on a histological study of a series of experimental fractures produced in the rabbit. It was also found necessary to consider fairly extensively the phenomenon of metaplasia. The question of bone neoplasms is also referred to, not only with regard to terminology, but also to study the potentialities of the involved cells as demonstrated in their differentiation. The summation of the evidence indicated that certain factors are of definite importance in the process of repair and these are discussed.

The experimental fractures were produced in the rib and fibula of the rabbit. The former bone was broken by pressure in the anaesthetized animal, the latter was divided by forceps in an open operation. Those bones necessitated no measures for splinting. The fractures ranged in age from twenty-four hours to twenty-eight days. Twelve animals were used. The specimens were fixed, either in formalin or Zenker's solution. The bones were decalcified in five per cent. nitric acid and were sectioned by the paraffin method. The majority of the sections were stained by hematoxylin and eosin.

Before examining the nature of the reaction of the cells in relation to bone repair it is important to eliminate, as far as possible, indefiniteness of terminology. It is very evident in the literature that lack of precision in this respect has given rise to an enormous amount of confusion, making it impossible at times to compare results. The first cell to be considered is the adult bone cell, about which no dissension can arise if the adjective "adult" is retained. The term "osteoblast" is at this time very difficult to define and this problem will be considered later. The cells which line the bone in the periosteum, endosteum, and haversian canals are the center

of a considerable amount of controversy. They will be discussed from a histological standpoint, after which a provisional name will be given them.

Considering first the literature regarding the histology of these cells, a fairly uniform opinion is found. Jordan finds that "After growth of the bone has ceased, the deepest layer of the periosteum contains few small blood vessels and only occasionally osteoblasts. . . . The medullary surface of the bone is likewise supplied with an osteogenic membrane of fibrocellular tissue similar to the innermost layer of the periosteum, . . . endosteum." Bailey may be quoted as follows: "In the adult bone it (the osteogenic layer of the periosteum) is represented by a single row of cubical or flattened cells". Piersol finds an osteogenic layer of the periosteum present during periods of growth, but in adult periosteum only represented by scattered groups of flattened cells. Schäfer expresses much the same opinion. Leriche and Policard are, however, definitely opposed to the idea that these specific cells exist and state, "It is impossible to find in these cells cytological characters which allow of their being distinguished from those of connective tissue". Key, however, as one of the translators of the English edition of Leriche and Policard, expresses himself to the effect that he believes the internal layer of the periosteum can be demonstrated in histological preparations of almost any bone, and especially well in the bones of young animals.

Discussing next the lining cells of the haversian canals, Shipley may be quoted as follows: "The haversian canals are like the medullary space lined with osteoblasts and filled with loose delicate reticular tissue. Blood vessels, usually an artery and one or more thin-walled veins run in them and lymphatic vessels may be found in the larger ones, while in the smaller the lymphatic system is represented by perivascular spaces. Vasomotor nerves are also of necessity present in them and the larger spaces contain marrow. Even in the smallest a few hematopoietic cells are present. In short the haversian canal is a finger-like projection from the marrow cavity about which bone has been built, and contains the same structures which are found in the cavum medullare itself, from which the canal is a branch." Bast, Sullivan and Geist have also described the osteogenic tissue lining the exterior and interior surfaces of the bone together with the haversian canals and state that the latter are derivatives of the first. Berg and Thalhimer put the matter very concisely in stating, "The endosteum is formed of osteoblasts which arise from those lining the periosteum and the osteoblasts also extend from the endosteum and the osteoblastic (cambium) layer of the periosteum into the haversian canals and line them".

On summing up the histological evidence, it appears that bone matrix tends to be separated from other adjacent tissues by a more or less complete investment of lining cells which are all of the same nature. These lining cells are found in the deep layer of the periosteum, and in the haversian canals; and they make up the endosteum. Morphologically they may be differentiated from the fibroblasts in the outer layers of the periosteum. These lining cells are often referred to in the literature as osteoblasts. Other

authors refer to them as osteogenic cells. The latter term indicates a somewhat broader meaning, probably because of its use in the terminology of bone tumors. In this respect Codman gives a most interesting definition of the word. He suggests that "osteogenic" "does not mean bone-forming but derived from bone, in the sense in which it is used as applied to bone tumors, nor does it mean strictly derived from bone, but derived from the tissues presumably intended to form bone". This term appears to be an excellent one to use when referring to these lining cells of bone, and although certain powers are granted to them by the name, it will become obvious that this is justified.

Having decided on the presence of these two cellular types,—namely the adult bone cells, and the osteogenic cells—we are prepared to investigate the reaction of each to injury. This will be done under two headings,—first, the adult bone cell; and second, the osteogenic cell. As it becomes extraordinarily complicated to follow the progress of the osteogenic cells of all three situations, the description will be limited to the behavior of those in the deep layer of the periosteum. The others exhibit the same type of reaction but are not nearly so important. This has also been noted by Bast, Sullivan and Geist.

THE BEHAVIOR OF THE ADULT BONE CELLS FOLLOWING A FRACTURE

Examination of one, two, three, four, and six day fractures shows a progressive and definite death of the adult bone cells situated near the line of

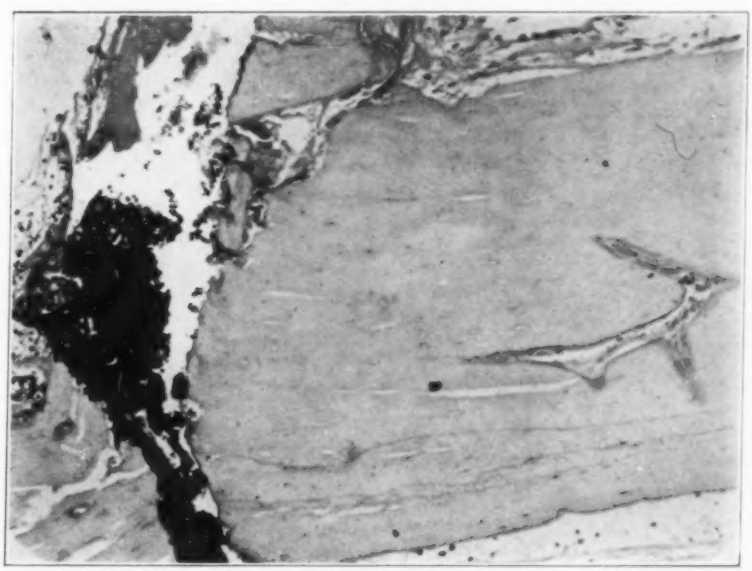

FIG. 1

Photomicrograph of fragment of fibula in a three-day fracture. × 120. Note the empty lacunae denoting death of the adult bone cells.

FIG. 2-A

Photomicrograph of a completely detached fragment of bone in a three-day fracture. × 120.

FIG. 2-B

Photomicrograph of portion of same fragment. × 400. Note the empty lacunae denoting death of the adult bone cells.

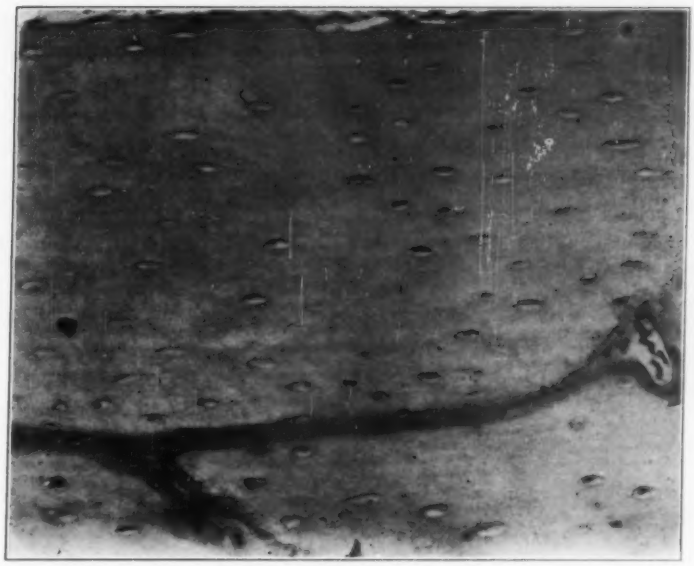

FIG. 3

Photomicrograph of rib at the junction of the living and the dead bone, in a three-day fracture specimen. × 400.

fracture (Fig. 1). In the rabbit's ribs this distance of dead bone varies from one to five millimeters. Small, completely detached fragments of bone suffer the same fate (Fig. 2). Contrary to Macewen's idea of these being centers of osteogenesis, it appears that in fractures the adult bone cells of these chips quickly undergo necrosis. The lacunae are either empty or they contain pyknotic and necrobiotic nuclei. Passing beyond the zone of necrosis to healthy bone, one finds a few and later all of the lacunae with adult bone cells of a normal appearance (Fig. 3). These cells evidence no sign of proliferation. It is quite evident that the adult bone cell takes no active part in the process of repair. These observations are in accord with others which may be found in the literature. Blaisdell and Cowan found the bone cells in the vicinity of the fracture line to be always destroyed. Berg and Thalhimer are quite definite when they state, "Fully developed bone cells, in the accepted sense of this term,—that is, cells within well calcified lacunae—have never been shown by microscopical observation to have divided and formed new bone". Mayer and Wehner recorded similar observations regarding the regenerative ability of the adult bone cells. Rohde also supports this conclusion. It is extraordinary that so much evidence must be offered to definitely establish this point, because in viewing broadly the regeneration of tissue it is quite obvious that as a cell becomes more specialized as to function its powers of regeneration diminish. The adult bone cells are highly specialized and must be regarded as Mallory has so concisely stated, "Bone cells are an end product and have lost the power of proliferation so that they play no part in the regeneration of bone".

THE BEHAVIOR OF THE OSTEOGENIC CELLS FOLLOWING FRACTURE OF THE BONE

As noted previously, for the sake of simplicity, the behavior of only the osteogenic cells of the periosteum will be carefully described. The osteogenic cells of the haversian canals and endosteum exhibit the same type of reaction, but to a lesser degree.

FIG. 4-A

Photomicrograph showing the osteogenic layer of the periosteum at a site approximately one centimeter from the site of fracture in a four-day specimen. × 240.

FIG. 4-B

Photomicrograph showing the proliferating osteogenic cells at a site fairly close to the line of fracture in the same four-day specimen. × 240.

Upon examining sections of a four-day fracture it becomes evident that there is a marked thickening of the osteogenic layer of the periosteum near the injury (Fig. 4). On closer examination it is seen that this is due to a marked increase in the number of cells, and to a lesser degree to an increase in the extracellular substance. The nuclei of these cells show a marked tendency to hyperchromatosis, and many of the cells are in various phases of mitosis. On the whole, the exhibition of cellular growth about a fracture is one of the most remarkable seen in the human body outside of malignancy. Ewing has commented on this. It is not at all uncommon to encounter four mitotic figures in a single high-power field. The periosteum may be traced, as it is in the photomicrographs, from a point at some distance to the site of the fracture, and it is seen that the thickening and cellular proliferation is definitely continuous with the osteogenic layer (Fig. 4). One section in particular presented a good example of the response of this layer of cells, as they may be seen to be in a state of active proliferation in a site which was separated from the fracture by the insertion of a tendon into the bone (Fig. 6).

FIG. 5

Photomicrograph of the area resulting from the proliferation and differentiation of the osteogenic cells adjacent to the line of fracture in a four-day specimen. × 240. Note that the osteogenic cells have differentiated into both cartilage and bone.

The first change in the osteogenic layer of the periosteum, following a fracture, is concerned with a great increase in the number of cells. This process is not the only one, and it is closely associated with the second which concerns the differentiation of the cells resulting from the proliferation.

On examining this cellular growth in its early phases (four to six days), we find the participating cells in all stages of differentiation (Fig. 5). About the exterior of the mass the cells persist in rapid proliferation which accounts for the continued growth of callus. Examining next the area situated beneath this actively growing zone, we find these newly formed cells laying down a matrix, and this is definitely of a cartilaginous type. It is

noteworthy that no blood vessels are discernible within this area. It is composed of a solid growth of osteogenic cells which are differentiating into cartilage cells. Turning now to the zone of osteogenic cells which are found in the area adjacent to the shaft of the bone, we find new bone formation. The osteogenic cells in this area have completed their differentiation directly into bone. Blood vessels are to be found in this area, and these are situated in newly forming marrow cavities.

Our observations regarding the behavior of the osteogenic cells of the periosteum may therefore be summed up as follows:

1. There was an extraordinary cellular proliferation in this layer (Figs. 4 and 6).
2. The resulting cells showed differentiation into both cartilage and bone cells (Fig. 5).
3. The cartilaginous tunic has formed in the zone situated beneath the actively growing peripheral region. This area showed no blood vessels (Fig. 5).
4. The young bone formation occurred in the portion of the osteogenic growth situated close to the shaft and blood vessels were found in this area (Fig. 5).

Definite as our evidence appears to be, we must still hesitate to draw conclusions concerning the osteogenic power of the periosteum. We must remember, as many have neglected to do, that in performing experiments in the field of bone and connective tissue, we are working in an area in which metaplasia occurs with notorious ease, and that this factor must be ruled out before granting inherent osteogenic capabilities to the deep cells of the periosteum.

We find then that we may consider two hypotheses regarding the production of the cellular growth about a fracture:

1. That the osteogenic cells of the periosteum are present normally in a somewhat undifferentiated state, and that the production of bone and cartilage from them involves no anaplasia. This hypothesis grants an inherent inclination to the osteogenic cells to form tissues of the osteoid group.

2. That the deep cells of the periosteum are fibroblasts, and that the production of cartilage and bone is the result of metaplasia (preceded by anaplasia). This hypothesis presumes that the fibroblasts of the periosteum are similar in nature to other fibroblasts.

A third hypothesis which assumes that the regeneration of bone takes place from the adult bone cells is not being entertained because of the convincing evidence already presented which proves their incapacity in this direction. Practically all of the evidence which has been offered in support of the theory that bone cells regenerate is of an indirect nature and has arisen in a rather curious way. Various investigators who performed surgical experiments from which they drew the conclusion that the periosteum was not osteogenic, were forced to assume that bone cells possessed these properties. The literature is peculiarly devoid of direct histological evi-

FIG. 6-A

Photomicrograph of the periosteal proliferation in an area on the fibula separated from the line of fracture by the insertion of a tendon in a four-day specimen. × 60.

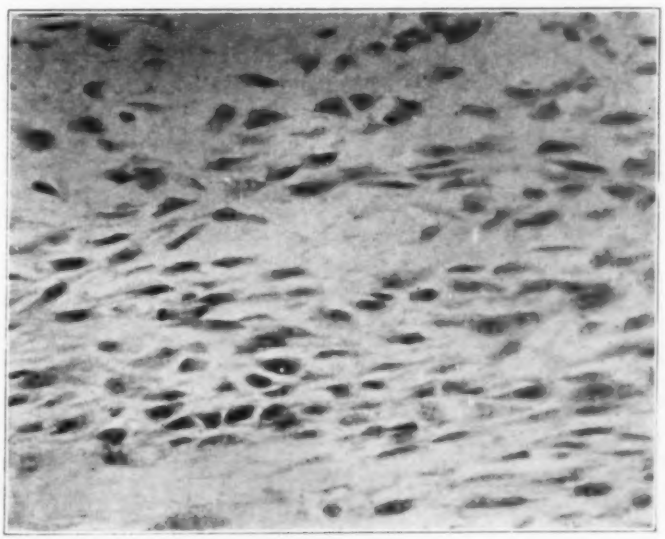

FIG. 6-B

Photomicrograph of same area. × 400. Note the proliferative activity of the osteogenic cells with the presence of two well marked mitotic figures.

dence of bone cells being a factor in regeneration, but there are innumerable reports which endeavor to show that the periosteum is not osteogenic. Macewen's conclusions regarding both the periosteum and the adult bone cell have been shown to be erroneous by both Mayer and Wehner, and Berg and Thalhimer in their most comprehensive articles. Gallie and Robertson, however, adhere to Macewen's theory regarding the periosteum but do not share his belief regarding the regenerative ability of the bone cell in transplants. They speak of the subperiosteal osteoblasts of the osteogenic layer of the cortex, but as Smith, Mayer and Wehner, and Berg and Thalhimer have shown, these cells really belong to the periosteum, while the description of them as belonging to the bone represents a surgical conception of the periosteum rather than an anatomical one.

Stump continues to support Macewen's contention. Whereas Macewen's research should not be underestimated, it is evident that he never proved the theory that adult bone cells participated in the process of repair.

It appears then that the status of the adult bone cell in regeneration is settled. No positive evidence has yet been offered to support the theory that it participates to any practical extent in the repair of bone. An enormous amount of excellent evidence has been offered to show that it takes no active part in the process of regeneration. Consequently, the hypothesis that presumes it to be of great importance will not be considered further. The subsequent discussion is related to the two previously elaborated hypotheses, and as one of these hinges on the phenomenon of metaplasia, this matter will now be investigated.

Adami defined metaplasia as follows: "Metaplasia is the postnatal production of specialized tissues from cells which normally produce tissues of other orders, and is an adaption on the part of the cells to altered environment". Regarding this phenomenon he also stated, "Metaplasia is not direct but can be brought about only by a preliminary reversion to a vegetative type of cell, or, where mother cells are present, by the development of cells modified by environment". Numerous examples of metaplasia are to be found in the literature. A very early and striking one was that of Sacerdotti and Frattin who tied the renal vessels on one side of four rabbits and in three months found true bone formation adjacent to the calcium deposits in the necrotic tissues. In 1906 Bunting, in discussing bone formation in a sclerotic aorta noted that, "in all the cases the bone had been formed when young connective tissue had come into contact with calcium deposits. The metaplasia is apparently the result of the chemical stimulus of the calcium salts." Harvey in 1907 experimentally caused bone to be produced in the arterial wall by painting the exterior with caustics. He believed the bone formation to be due to the metaplasia of connective tissue adjacent to areas of calcareous deposits. Buerger and Oppenheimer in 1908 observed that, "It is generally conceded that the presence of lime and young connective tissue is essential to heteroplastic bone formation". Klotz in discussing this process states, "The formation of bone within the arteries is brought about by a process not uncommonly seen in other tissues.

The process is usually one of primary calcareous degeneration followed by an unusual vascularization around the area of deposit. It is in this vascular area that a metaplasia of the connective tissue leads to bone formation." Keith, in discussing some cases of this nature, expressed the opinion that cells from the winding vascular buds may become osteoblasts. Maximow expressed himself regarding the fibroblast as follows: "The typical fibroblasts are highly differentiated elements, incapable of producing other cell types. The connective tissue contains numerous undifferentiated mesenchymal cells, especially arranged along the capillaries (for instance, in the omentum) and these cells, of course, can produce any type of connective tissue or blood cells and in inflammation and tissue culture indeed are often seen to function as an additional local source of polyblasts (macrophages)." This viewpoint, if accepted, could modify considerably our conception of the manner of formation of the osteoblast in metaplastic bone formation, in that we would not have to assume an anaplasia on the part of the fibroblast but rather an increasing differentiation of an embryonic type of cell. Rohde believes metaplastic bone to be derived always from undifferentiated cells and not from fibroblasts.

Leriche and Policard have fairly recently placed great emphasis on the importance of metaplasia in the repair of bone. They do not believe in the specific osteogenic power of the periosteum. Their viewpoint, however, must not be confused with that of others which supported the theory of the periosteum possessing no osteogenic properties. Whereas Haller, Goodsir, Macewen, Gallie and Robertson, Ely, Stump, and Moore and Corbett hold this latter view, it is obvious that they believe regeneration to be effected by other cells of the bone. Leriche and Policard, on the other hand, express themselves as follows: "Thus, contrary to the classical opinion, we think that the periosteum has no specific osteogenic virtue whatever. It is only a site for ready ossification for the simple reason of its juxtaosseous situation. But any fibrous connective membrane close to a calcified or bony mass will possess the same properties. It should not arise in the mind of anyone to attribute to this membrane a specific osteogenic power."

Having reviewed metaplasia in its relationship to bone formation, we are now prepared to consider the two hypotheses offered previously. We shall do this first by comparing the process of healing in a fracture to metaplastic bone formation, and secondly by studying the inherent power of the periosteal cells by examining their behavior in their neoplasia.

THE CHARACTER OF THE CELLULAR GROWTH ABOUT A FRACTURE COMPARED WITH THAT SEEN IN METAPLASTIC BONE FORMATION

Metaplastic bone formation occurs where calcium salts are associated with an area of unusual vascularization. Although it must be admitted that the term "granulation tissue" may be used at times with certain latitude, the usual definition of it insists that there should be many young blood

vessels in it. In studying the osteogenic growth about the fracture, it would seem that there is a portion of the growth which is peculiarly devoid of blood vessels (Fig. 5). The growth of the osteogenic layer of the periosteum is so marked that the usual picture leads one to believe that the response to growth by these osteogenic cells was so profuse that many areas by their own proliferative activity have shut themselves off from a blood supply. The inner zone of the early callus developing from the periosteum close to the fractured bone shows a few blood vessels (Fig. 5). The outer zone of the callus shows blood vessels derived from those of the outer layers of the periosteum. Between these two zones there is a definite area which on histological examination shows few or no vascular channels. This is the area in which differentiation into cartilage occurs (Fig. 5). Consequently it does not seem proper that the mass of tissue arising from the marked response of the osteogenic cells should be spoken of as granulation tissue. It is, on the other hand, peculiarly free, especially in certain zones, from the capillary element which is of prime importance in granulation tissue. This picture is different from the usual one seen in metaplastic bone formation where a highly vascular granulation tissue is a prominent feature. Klotz has pointed out the close association between granulation tissue, calcium salts, and metaplastic bone formation. It does not appear, however, that this relationship is as intimate in the usual repair of a fracture. Consequently we are forced to conclude that the two processes, metaplastic bone formations on the one hand and bone repair on the other, are not similar, and that the early growth about a fracture is due to the specific response on the part of the osteogenic cells, and that it is not a result of a true metaplasia.

THE INHERENT PROPERTIES OF THE OSTEOGENIC CELLS AS DEMONSTRATED IN THEIR NEOPLASIA

It seems to be quite relevant at this time to study these cells in their neoplasia. Here we find a marked difference between the manifestations of the fibroblast and the osteogenic cell. That the types of tissue observed in osteogenic sarcoma are not the result of metaplasia is expressed by Ewing who may be quoted as follows: "The observed facts do not seem to require the theory of a metaplastic development of any common type of bone sarcoma". Codman carefully distinguishes between periosteal fibrosarcoma and periosteal osteogenic sarcoma. Regarding the former, he says, "Roentgenologically they may show changes in the contours of the adjacent bones, even pushing the bones to one side or bending them, but histologically they show no tendency to form osteoid tissue, cartilage, or bone. It is this that separates them from one class of periosteal osteogenic sarcomas, which presumably arise from the osteoblastic layer of the periosteum. Periosteal fibrosarcomas are not distinguishable histologically from fibrosarcomas of the fascia." McCallum speaks of sarcomas "which are developed from the periosteum and the endosteum and which metastasizing have retained the power of bone-forming cells to elaborate all the types of

connective tissue concerned in the formation of bone". Ewing carefully differentiates between periosteal sarcoma (extraperiosteal sarcoma) "a tumor, although derived from periosteum, the cells of origin probably do not include the osteoblasts and the tumors show very little tendency to form bone", and the medullary and subperiosteal osteogenic sarcoma which does produce immature and atypical bone, cartilage, and osteoid tissue by pleomorphic cells.

We find then, that not only in the growth and regeneration of bone, but also in certain tumors arising in bone, the osteogenic cell possesses specific properties or tendencies which separate it from the fibroblast. The presented study of fractures together with other reports indicate that bone repair is usually accomplished by the proliferation of these osteogenic cells, particularly those of the periosteum. Consequently there does not appear to be any reason to believe that the usual method of bone repair is that of metaplastic bone formation by fibroblasts. Whereas, the ease with which bone may form by metaplasia is appreciated, it does not seem that this is the manner in which the usual fracture heals. On the contrary, the usual healing of a fracture is due to the proliferation and differentiation of osteogenic cells which are specifically adapted to the purpose.

We have found that osteogenic cells in the repair of fractures may differentiate into either bone or cartilage. It is also very significant that all gradations between the two types of tissue may be found. The fundamental point now arises as to whether or not the production of bone or cartilage depends on the presence of two differentiated sub types of cells,—namely osteoblasts and chondroblasts—which possess, in themselves, inherent power to differentiate into only one of the two types of tissue.

To examine this question, much help is found in tracing osteogenic cells through this complete history. Beginning with perichondrial cells in the embryo, it is found that these cells are able to produce both cartilage and more perichondrial cells. Sometime later the name of the perichondrium is changed to periosteum because direct derivatives of these same cells now lay down bone and also give rise to more periosteal cells. In the adult, in the repair of a fracture, these periosteal cells give rise again to both cartilage and bone. In tumors arising from these cells both cartilage and bone are formed. The nature of these osteogenic cells is the same, whether they are called perichondrial or periosteal, and the reason that bone or cartilage is found is all a result of the environment under which these cells are growing.

Studying now the different environments under which bone or cartilage is formed, we find, in both the development of cartilage and bone and the repair of fractures, that the same circumstances are responsible for the kind of tissue produced. In both the embryo and in the repair of fractures, osteogenic cells in the presence of a good blood supply, and adjacent to a local deposit of calcium salts, will differentiate into bone cells. On the other hand, proliferating osteogenic cells, in the absence of a local deposit of calcium salts and a blood supply, will differentiate into cartilage.

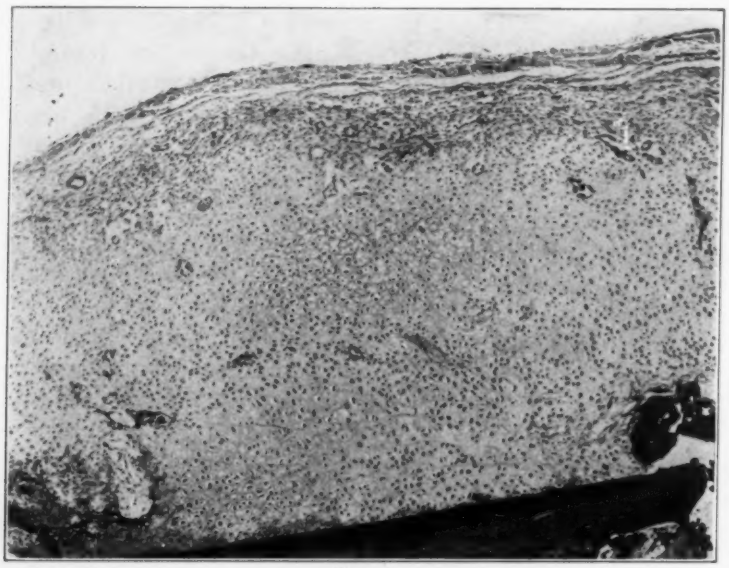

FIG. 7
Photomicrograph of a long spicule of dead bone covered by a large mass of cartilage, in a twenty-one day specimen. × 12.

In the cartilage of the embryo, bone is first laid down in the subperiosteal area, and in the ossification center of the shaft. In both of these areas there is a preceding calcification of the cartilage matrix. The subperiosteal area has a good blood supply derived from the vessels of the periosteum. The blood supply of the ossification centers is furnished by the vessels which grow in along with the periosteal bud. Consequently the same type of cell which previously had given rise to cartilage now gives rise to bone.

In the repair of fractures, the same type of procedure is followed. After the proliferation of the osteogenic cells takes place, we find that the cells situated close to a local deposit of calcium salts and provided with a blood supply, differentiate immediately into bone. This is found along the line of the old bone, which provides both the local deposit of calcium salts and the blood supply for a limited area close to it. Consequently we could expect to find the first new bone formation close to the old shaft where the bone is still alive, because if the bone were dead, it could not furnish an early blood supply to the osteogenic growth adjacent to it. It is noted that in Figure 7 an unusually long spicule of bone died following the fracture, and this is seen to be covered with an osteogenic growth which has differentiated into cartilage. If this growth is traced along the spicule to the region where the old bone is still alive, the osteogenic cells close to the blood supply derived from the healthy shaft are found to have differentiated directly into bone.

Turning now to the portion of the osteogenic growth which is further removed from the original bone, we find that there is an almost solid cellular proliferation of osteogenic cells with no blood vessels in it. Consequently differentiation into cartilage has occurred. In the exterior of the

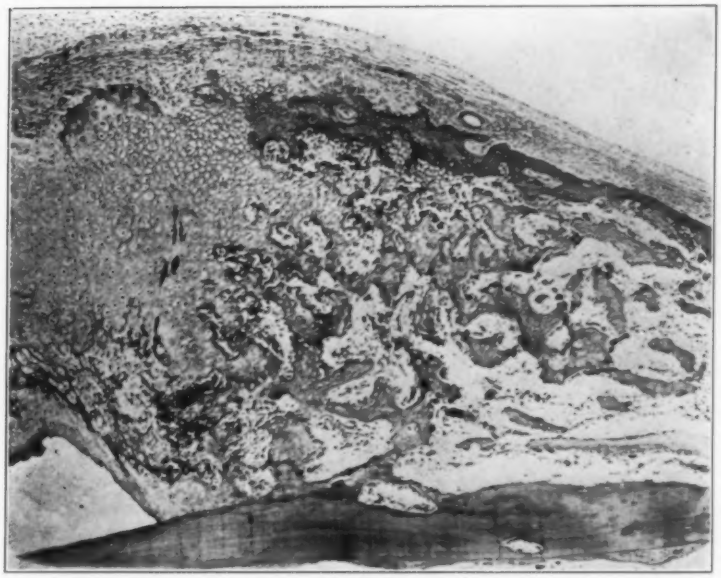

FIG. 8

Photomicrograph of a twenty-eight day specimen of fractured rib, in which the cartilage is being replaced by bone. × 12. Note that the developing marrow spaces contain blood vessels so that the invading osteogenic cells are able to differentiate directly into bone on the surfaces of the old calcified cartilage.

callus a blood supply is found but here the area is so far removed from the local deposit of calcium salts that differentiation in either direction is not marked, the cells remaining an osteogenic type (Fig. 5).

It is most interesting in this respect to examine the way in which the cartilage in a fracture is replaced by bone, and not by more cartilage (Fig. 8). As the cartilage of the callus becomes older, the matrix becomes calcified and the lacunae enlarged, so that they often coalesce (Fig. 9-A). The spaces thus formed are invaded by osteogenic cells which are accompanied by blood vessels. Consequently the osteogenic cells in the presence of the calcified cartilage matrix and a good blood supply differentiate directly into bone.

This evidence points strongly to the fact that the osteogenic cells cannot be called osteoblasts or chondroblasts. This presented conception of the osteogenic cell would also deny the presence of the pathological entity of a type of tumor arising in bone and known as either an osteoblastoma or a chondroblastoma. It would explain the presence of both bone and cartilage in osteogenic tumors, whether benign or malignant.

Whereas it has been my intention to stress the importance of a specific cell for osteogenesis and the profound effect that environment plays upon its differentiation, it is not to be assumed that the local factors are the only important ones or that bone and cartilage cells are the only products of the cellular differentiation. Other factors, such as vitamin D and the para-

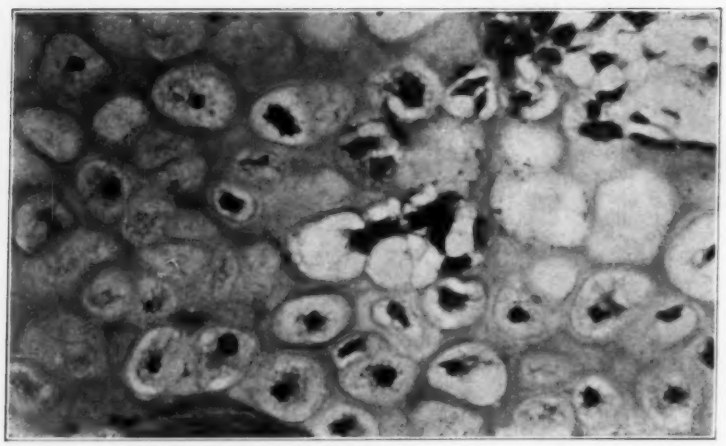

FIG. 9-A

Photomicrograph of the cartilage in a seventeen-day specimen of healing fracture of the fibula. × 400. Note the evidences of degeneration and necrosis in many of the cartilage cells and the extremely fragile structure of the calcified cartilage matrix which in areas has allowed lacunae to coalesce.

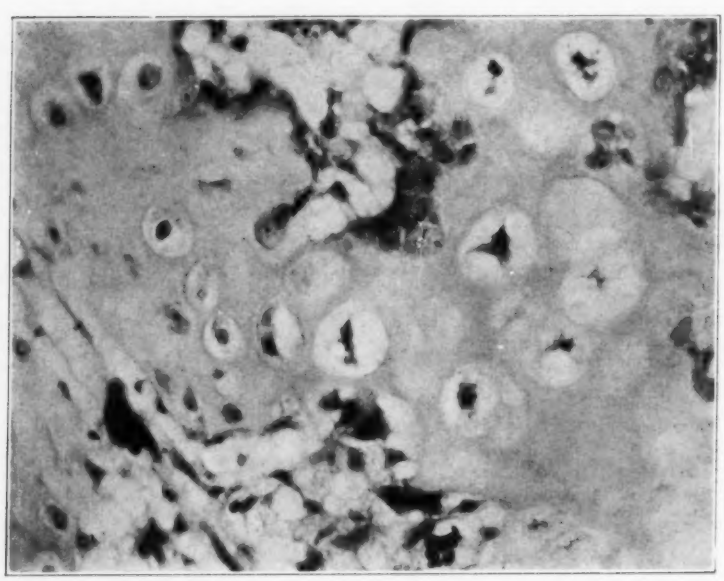

FIG. 9-B

Photomicrograph of cartilage in seventeen-day specimen of healing fracture of fibula. × 400. Note that the cavities in the cartilage matrix are being invaded by osteogenic cells. These may be seen lining the cavity in the center of the upper part of the picture.

thyroid secretion, play a most important part; but their study is a separate problem. Furthermore, it seems quite possible that osteogenic cells may also differentiate into giant cells. Work on this problem is in progress and will be reported on shortly.

SUMMARY

The adult bone cell is distinguished from the osteogenic cell which is found lining the bone in the periosteum, the haversian canals, and the endosteum.

The adult bone cell was found to take no active part in the process of regeneration of bone following a fracture.

The osteogenic cells proliferate and differentiate into bone and cartilage.

Concerning the controversy regarding the existence of a specific osteogenic cell, the subject of metaplastic bone formation is reviewed. The usual method of bone repair is through the agency of these specific osteogenic cells and not by the metaplasia of fibroblasts.

Two factors, the presence of a local deposit of calcium salt and a good blood supply, are of great importance in effecting the differentiation of the osteogenic cell into bone.

Cartilage results from the growth of osteogenic cells in the absence of these two factors.

In the repair of fractures, bone and cartilage formation result from the differentiation of osteogenic cells in different environments.

My sincere thanks are due Prof. Oskar Klotz, whose inspiration and kindly assistance were of inestimable value throughout the course of this work.

BIBLIOGRAPHY

1. Duhamel: Taken from Keith.
2. Haller: Taken from Keith.
3. Keith, Sir Arthur: Menders of the Maimed. Ed. 1. London, Oxford University Press, 1919.
4. Jordan, H. E.: Textbook of Histology. Ed. 2. New York, D. Appleton and Co., 1925.
5. Bailey (Strong, O. and Elwyn, A.): Textbook of Histology. Ed. 7. New York, Wm. Wood and Co., 1925.
6. Piersol, G. A.: Normal Histology (Addison). Ed. 13. Philadelphia, J. P. Lippincott Co., 1927.
7. Schäfer, E. A.: The Essentials of Histology, Descriptive and Practical, for the Use of Students. Ed. 11. Philadelphia, Lea and Febiger, 1920.
8. Leriche, R. and Policard, A.: The Normal and Pathological Physiology of Bone; Its Problems. (Authorized English translation by Moore, S. and Key, J. A.), Ed. 1. St. Louis, C. V. Mosby Co., 1928.
9. Key, J. A.: The Normal and Pathological Physiology of Bone; Its Problems. By Leriche and Policard. (English translation), Ed. 1. St. Louis, C. V. Mosby Co., footnote p. 109, 1928.
10. Shipley, P. G.: Special Cytology. Ed. 1. New York, Paul B. Hoeber, Inc., Vol. II, Section XX, 1928.

11. Bast, T. H., Sullivan, W. E., and Geist, F. D.: The Repair of Bone. Anat. Record, XXXI, 255, 1925.
12. Berg, A. A. and Thalhimer, W.: Regeneration of Bone. Ann. Surg., LXVII, 331, 1918.
13. Codman, E. A.: Bone Sarcoma. Ed. 1. New York, Paul B. Hoeber, Inc., 1925.
14. Macewen, W.: The Growth of Bone. Ed. 1. Glasgow, James Maclehose & Sons, 1912.
15. Blaisdell, F. E. and Cowan, J. F.: Healing of Simple Fractures. Arch. Surg., XII, 619, 1926.
16. Rohde, Carl: Does Bone Form from Osteoblasts or from a Metaplasia of the Surrounding Connective Tissue? Surg., Gynec., Obstet., XLI, 740, 1925.
17. Mallory, F. B.: Principles of Pathologic Histology. Ed. 1. Philadelphia, W. B. Saunders Co., 1914.
18. Ewing, J.: Neoplastic Diseases. Ed. 3. Philadelphia, W. B. Saunders Co., 1928.
19. Mayer, Leo and Wehner, E.: An Experimental Study of Osteogenesis. Am. J. Orthop. Surg., XII, 213, Oct. 1914.
20. Gallie, W. E. and Robertson, D. E.: The Repair of Bone. British J. Surg., VII, 211, 1920.
21. Smith, F. D.: Periosteal Regeneration of Bone. Surg., Gynec., Obstet., XX, 547, 1915.
22. Stump, C. W.: The Histogenesis of Bone. J. Anat., LIX, 136, 1924-1925.
23. Adami, J. G. and McCrae, J. A.: Text-book of Pathology, for Students of Medicine. Ed. 2. Philadelphia, Lea and Febiger, 1914.
24. Sacerdotti, C. and Frattin, G.: Über die heteroplastische Knochenbildung. Virchows Arch. f. path. Anat., CLXVIII, 431, 1902.
25. Bunting, C. H.: The Formation of True Bone with Cellular (Red) Marrow in a Sclerotic Aorta. J. Exper. Med., VIII, 365, 1906.
26. Harvey, W. H.: Experimental Bone Formation in Arteries. J. Med. Res., XVII, 25, 1907.
27. Buerger, L. and Oppenheimer, A.: Bone Formation in Sclerotic Arteries. J. Exper. Med., X, 354, 1908.
28. Klotz, O.: Fracture of Arteries. J. Med. Res., XXIX, 495, 1916.
29. Keith, Sir Arthur: Concerning the Origin and Nature of Osteoblasts. Proc. Roy. Soc. Med., XXI, 301, 1927.
30. Maximow, A. A.: Special Cytology. Ed. 1. New York, Paul B. Hoeber, Inc., Vol. I, Section XIV, 470, 1928.
31. Goodsir, J.: Taken from Keith.
32. Ely, L. W.: Experimental Study of the Healing of Fractures. Arch. Surg., V, 527, 1922.
33. Moore, J. and Corbett, J.: Studies on the Function of the Periosteum. Surg., Gynec., Obstet., XIX, 5, 1914.
34. McCallum, W. G.: A Textbook of Pathology. Ed. 3. Philadelphia, W. B. Saunders Co., 1925.

AN OPERATION FOR THE CURE OF PARALYTIC GENU RECURVATUM*

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Although a few degrees of hyperextension of the knee frequently give stability to a paralyzed joint which would otherwise be incapable of bearing the body weight, genu recurvatum of twenty-five degrees or more constitutes a serious handicap to locomotion. In the case of marked deformity—fifty degrees or more,—walking is impossible, and even with a well fitted brace patients are usually helpless. It was to overcome this deformity that Willis Campbell in 1918 published his method of implanting the patella into the upper end of the tibia. Previous to Campbell's operation, moderate grades of recurvatum had been corrected by supracondylar osteotomy of the femur. In 1927 at the San Francisco Clinical Session of the American Orthopaedic Association, Dr. Bull demonstrated a method of correction by shifting the lateral ligaments; and Dr. Gill has devised a fascial plastic which is to be presented at the 1930 meeting of the Association. In mild cases in which the hamstring muscles are present and the recurvatum is due, as Volkmann showed long ago, to paralysis of the quadriceps, I have secured excellent results by transplanting the biceps and semitendinosus to the patella and reefing the posterior capsule of the joint.

The operation I am about to describe is not intended for the mild cases, but for the severe grades. It was suggested by Campbell's patella implantation, the principle of which appealed to me strongly, but in the practice of which I found two drawbacks:—first, the difficulty in freeing the patella sufficiently to permit its implantation; second, the relatively small size of the patella which failed to give a large enough bone block. It was my purpose to create an adequate bone block so attached to the tibia as to correspond to the olecranon process of the ulna,—in other words, to make an elbow joint out of the knee.

OPERATIVE TECHNIQUE

A mid-line incision is made, beginning three inches above the patella, extending downward to the tuberosity of the tibia, or, if the bone graft is to be removed from the tibia, three inches further. The skin is dissected back sufficiently to expose the lateral recesses of the joint. An inverted V-shaped incision is then made through the quadriceps tendon, running downward through the joint capsule on each side of the patella to within an inch of the lateral ligaments (Fig. 1). By retracting the patella downward this incision gives free access to the joint. To give a better exposure

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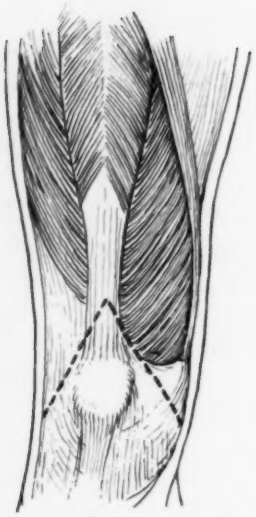

FIG. 1

Anterior view of the knee showing the line of incision through the quadriceps tendon and the capsule of the joint.

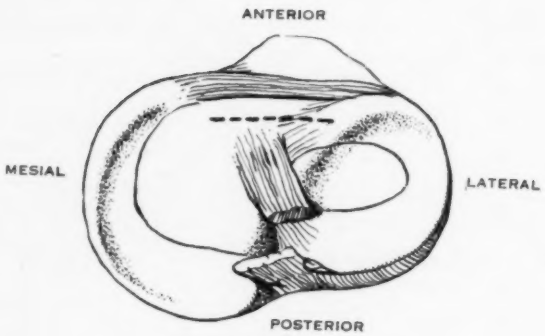

FIG. 2

View of the articular surface of the tibia showing the line of incision into the tibia. This lies directly in front of the attachment of the anterior crucial ligament to the spine of the tibia, and just posterior to the attachment of the internal meniscus. The chisel nicks the external meniscus near its attachment but does not completely sever it.

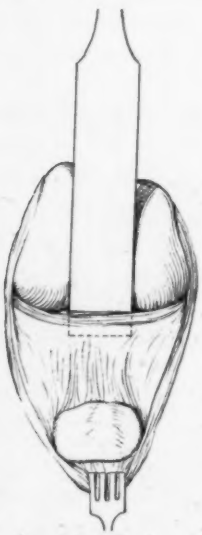

FIG. 3

The patella and patella tendon are retracted downward and the chisel, inserted along the line shown in Fig. 2, is driven vertically downward into the tibia for about one inch.

FIG. 4

Sagittal section through the knee joint after the implantation of the bone graft. The deep surface of the patella has been denuded of cartilage and makes contact with the rough surface of the graft. The smooth surface of the graft faces the femur.

of the upper end of the tibia, the ligamentum mucosum is divided and part of the retropatellar fat pad is excised. A one and a half inch chisel is then driven vertically downward into the tibia for a distance of one inch. The cutting edge of the chisel is placed at right angles to the anteroposterior axis of the knee, just between the attachment of the anterior crucial ligament and the internal meniscus (Figs. 2 and 3). That portion of the tibia lying anterior to the chisel is pried gently forward, so as to make room for a bone graft. This is taken either from the femur, or the tibia. It should measure approximately two and a quarter inches long, one and a quarter inches wide, and three-sixteenths of an inch thick. The end to be inserted into the tibia should be a trifle narrower and should be beveled to permit easier insertion. The femur is more accessible than the tibia since its lower end, covered with cartilage, lies exposed in the wound. The tibial graft, however, though requiring a prolongation of the original incision, is much more easily driven into the cleft made by the chisel. The graft, its smooth surface facing the joint, is driven downward into the tibia, leaving about one inch projecting from the upper surface of the tibia. The patella is next denuded of cartilage. It is found that the raw surface of the patella makes good contact with the raw surface of the graft (Fig. 4), thus insuring a solid union between them. The incision into the joint and quadriceps tendon is closed by continuous chromic stitches, the skin with a continuous fine plain gut.

CASE REPORTS

Twelve patients have been operated on by this method (Figs. 5, 6, 7, 8, 9, and 10), three during 1927, four in 1928, four in 1929, and one in 1930.

FIG. 5-A

Case 1 before operation. Patient was barely able to stand for the few minutes required for the photograph.

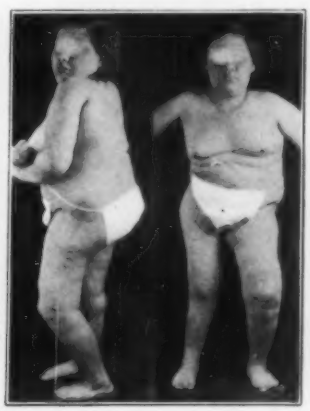

FIG. 5-B

Case 1, three years after operation. Patient is able to stand and walk without the aid of support. There is a tendency to hold the operated knee slightly flexed but the patient can straighten it to 180 degrees.

FIG. 5-C

Two photographs illustrating the range of motion. Angle of greatest extension 180 degrees, angle of greatest flexion 150 degrees.

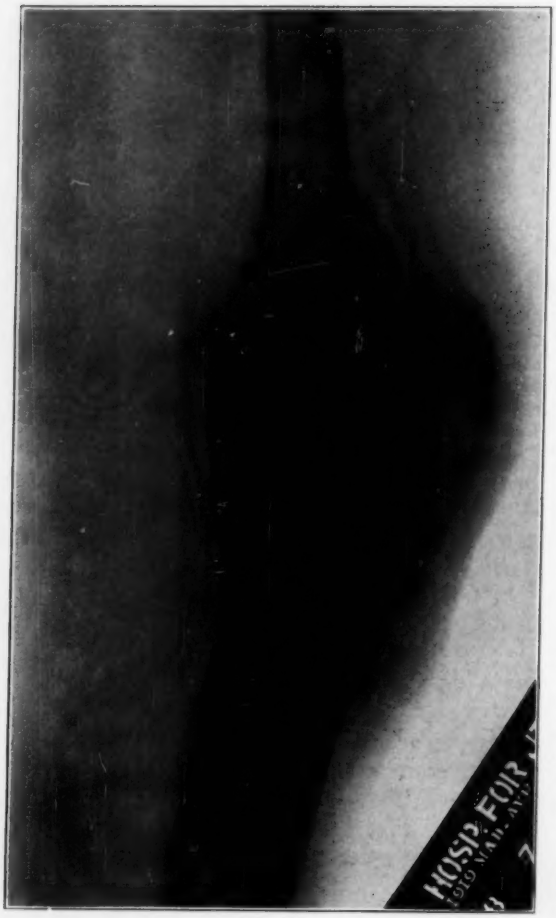

FIG. 5-D

X-ray three years after operation showing the hypertrophy of the bone graft and the fusion between it and the patella.

In all the patients the wound healed by primary intention and the recurvatum was completely cured; in none was there any complaint of pain in the knee when walking or even when the bone graft was forcibly jammed against the femur in an attempt to hyperextend. This fact is worthy of comment, since it indicates how extensive an intra-articular operation can be performed without exciting a harmful reaction. The range of motion varied from twenty-five degrees in one of the first cases (Fig. 5-C) to 135 degrees in the last two (Fig. 8-C). All the patients except one have learned to walk without a brace, despite the fact that none have power in the quadriceps or knee flexors and almost all have weak hip muscles. All have learned to climb stairs and this has been of great practical significance in enabling six of the group to attend high school and change from one classroom to another in competition with normal children. In one case a postoperative hemarthrosis formed and a secondary operation had to be done to evacuate the clotted blood. This patient subsequently developed seventy-five degrees of motion.

The one grave danger in the operation is overcorrection of the deformity, leading to a flexion contracture. No matter how slight, this will greatly interfere with the stability of the joint and will prevent the patient from placing the body weight solidly on the operated leg. In the fifth case of the series, the bone block hypertrophied to such an extent as to prevent extension beyond 170 degrees. A secondary operation was done six months after the first and part of the graft removed. Despite this, the result was unsatisfactory and I finally felt compelled to arthrodese the knee.

This experience led me to make two changes in the postoperative technique. In the first cases the knee had been flexed to ninety degrees and kept in this position eight to ten weeks. In the more recent cases the angle was changed to 135 degrees and the immobilization period shortened to four weeks. The resultant range of motion has been much greater and there has been less difficulty in gaining complete extension, without in any way interfering with the effectiveness of the bone block. It is possible that this phase of the treatment can be improved still further by immobilizing the knee in complete or almost complete extension, thus permitting a slight amount of hyperextension to develop.

The roentgenographic studies have demonstrated that in every case a fusion occurred between the tibia and the graft and between the graft and the patella (Figs. 5-D, 6-C, and 7-B). Almost all the grafts hypertrophied, thus bringing new proof of the correctness of Wolff's law (Figs. 9-A and 9-B). In some a change in the inner architecture of the bone was demonstrated by the ingrowth of the lamellae of the upper end of the tibia into the graft (Fig. 9-B). None of the femora showed evidences of erosion or pressure atrophy.

It might at first thought seem peculiar that a bone graft introduced into a joint

FIG. 6-A

Case 2, before operation.

FIG. 6-B

Case 2, two and a half years after operation. Patent can place her full weight on the operated knee without either recurvatum or flexion deformity.

FIG. 6-C

Lateral x-ray picture of Case 2, two and a half years after operation, showing the position of the bone graft and its fusion with the patella.

FIG. 7-A

Case 3, Photographs two years after the operation showing the range of motion from complete extension to flexion of 80 degrees. This patient has been able to discard braces and is able to walk and climb stairs without difficulty.

FIG. 7-B

Lateral x-ray picture of Case 3, two years after operation.

cavity should hypertrophy. We are all familiar with the futility of attempting to fuse the os calcis and the astragalus by driving a bone peg through the heel into the astragalus. This type of graft invariably atrophies and fractures when it passes through the joint. The same fate might seem to be in store for a graft introduced into the knee joint. The analogy is, however, quite incorrect. The genu-recurvatum bone graft does not span a gap between two movable bones nor does it traverse a joint. Although intra-articular at the time of its insertion, it soon becomes extra-articular, as was clearly shown by the secondary operation performed on the fifth patient of the series. Here the graft was found to occupy exactly the same relation to the joint as the olecranon process of the ulna to the elbow. Its deep surface was coated by a smooth pseudocartilage to whose margins the

FIG. 8-A

Case 9, Patient before operation.

FIG. 8-B

Patient standing, six months after the operation.

FIG. 8-C

Photographs illustrating the range of motion six months after the operation, from complete extension to flexion of 150 degrees. This patient illustrates the marked improvement in the range of motion which has been secured in all of the recent cases by diminishing the period of immobilization from ten weeks to four weeks.

FIG. 9-A

Lateral x-ray pictures of the knee of Case 7, six weeks after the operation.

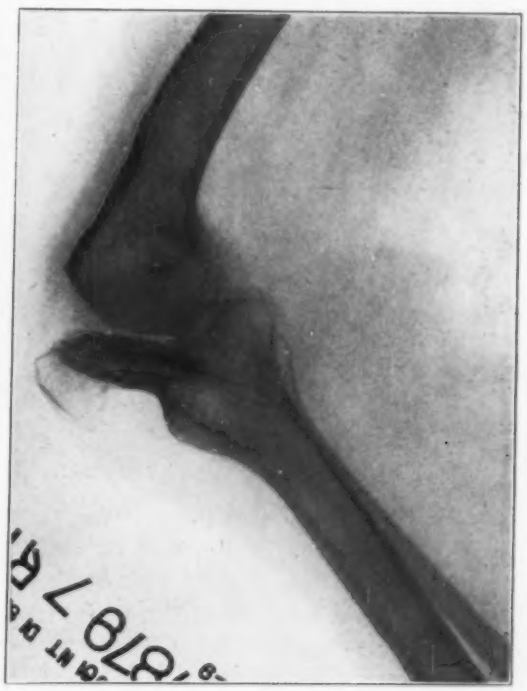

FIG. 9-B

One and a half years after the operation. These x-ray views illustrate clearly the hypertrophy of the graft when subjected to functional stress, and the ingrowth of the lamellae of the upper end of the tibia into the graft.

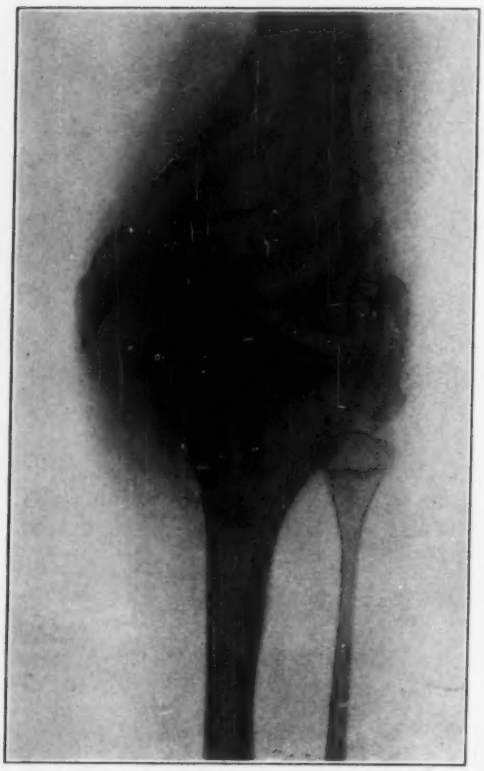

FIG. 10

Anteroposterior x-ray picture of Case 8. In this patient, in addition to the usual bone block, two lateral bone flaps were turned down from the condyles of the femur so as to minimize a marked lateral mobility. As a result of the lateral bone blocks, the lateral mobility has been diminished from 50 degrees to 10 degrees. The anterior bone block prevents recurvatum and the patient is able to walk without a brace.

synovial membrane was attached. The graft therefore, corresponds to a normal joint structure, and will hypertrophy in accordance with the functional demands placed upon it.

The eighth patient illustrates a modification of the operative technique worthy of comment. She had in addition to thirty-five degrees of recurvatum, fifty degrees of lateral mobility. Besides the usual bone graft, an attempt was made to overcome the lateral instability by turning down two lateral bone flaps from the femoral condyles, corresponding to the malleoli at the ankle (Fig. 10). The outer portion of the condyle was split off and rotated through an arc of 180 degrees so that the proximal portion became the distal. To close the gap in the joint capsule a free graft of fascia lata was inserted. The operation resulted in marked improvement. The patient today has no recurvatum and only ten degrees of lateral mobility. She is beginning to use the knee without a brace.

SUMMARY

Severe grades of genu recurvatum can be successfully treated by inserting a bone graft into the upper end of the tibia. The graft, fusing with the tibia and the patella, forms a bone block which effectually prevents hyperextension. The graft bears the same relationship to the tibia as the olecranon process to the ulna, and the operation might therefore be summarized as a conversion of the knee joint into an elbow. Great care must be taken not to maintain the overcorrected position too long, since otherwise a flexion contracture is likely to ensue.

A STUDY OF THE END RESULTS OF SYNOVECTOMY OF THE KNEE

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During the past ten years several papers on synovectomy have been published; and the history, merits and technique of the operation have been exhaustively discussed. It is not the purpose of this paper to enter into these matters, but merely to present a study of the end results of a series of operated cases. This series comprises sixty-five cases of knee synovectomies performed upon fifty-three patients in the Department of Orthopaedic Surgery of the State University of Iowa from the year 1921–1928, inclusive. The eighteen cases reported in 1925 by Dr. Arthur Steindler, the head of the Department of Orthopaedic Surgery of this University, are also included in this series.

The decision for a synovectomy was generally made by the head of the Department after study of the individual case. In accord with the expressed opinion of others, it is our belief that synovectomy is by no means a general treatment of chronic arthritis, but rather that it has a very limited field of usefulness among carefully selected cases. During the past nine years more than one thousand cases of arthritis of the knee came to this clinic for consultation and treatment. Less than six per cent. of these cases were treated by synovectomy. The majority of the synovectomies in this series were indigent cases. A few are reported from the private clinic of the head of this Department. The operations were performed either by Dr. Steindler or by a member of his staff.

The technique employed was, in general, the same as that recounted in the literature. In the earlier cases the knee joint was opened by the transpatellar route of Jones (56 per cent.). In more recent years the incision has been made medial to the patella (40 per cent.). In the remaining few cases (4 per cent.), a U-shaped incision was used. In some cases complete synovectomy was done, while in others the synovial membrane was partially removed. In still other cases the fat pad, and at times the semilunar cartilages were removed together with the synovial membrane. The wound was generally closed without drainage, and posterior splints of plaster were applied. Motion and physiotherapy were instituted to the parts as soon as the individual cases permitted. In cases of infectious arthritis, the general arthritic treatment, both dietetic and medicinal, and the treatment of the probable foci of infection were usually instituted before a decision for synovectomy was made.

The cases in this series are first divided into two groups: *a*. Polyarticular group, consisting of twenty-nine cases or fifty-four and five-tenths per

TABLE I

CASES OF SYNOVECTOMY

	No. of Synovectomies	Per cent.	Average Duration of Illness	
POLYARTICULAR TYPE				
29 cases — 54.5%				
Chronic infectious arthritis	36	55.9	3.2 yrs.	From .3 to 20 yrs.
Chronic hypertrophic arthritis	5	7.7	3. yrs.	From 1 to 5 yrs.
MONARTICULAR TYPE				
24 cases — 45.5%				
Chronic hypertrophic arthritis	3	4.6	1.5 yrs.	From .2 to 4 yrs.
Chronic atrophic arthritis	6	7.7	2.3 yrs.	From .7 to 8 yrs.
Traumatic arthritis	11	16.9	6.7 yrs.	From .25 to 15 yrs.
Tuberculous arthritis	3	4.6	6.7 yrs.	From 4 to 13 yrs.
Syphilitic arthritis	1	1.6	1 yr.	
Total patients — 53				
Knee synovectomies	65			

cent. of the total number of the cases, and *b*. Monarticular group comprising twenty-four cases or forty-five and five-tenths per cent.

Table I lists the number of synovectomies under the different types of arthritis, and also relates the average duration of the illness before coming to this clinic.

In classifying the end results of the cases of this series, we were obliged to discard five cases on account of insufficient follow-up after the operation. These cases were discharged from the hospital a few weeks after the operation as "improved", but they either did not return at all for check-up, or were observed by the Department for less than a period of one year. The remaining forty-eight patients comprising sixty synovectomies of the knee were under the observation of the Department from one year to ten years. The end results are divided into two general divisions, as "Improved" and "Unimproved". The "Improved" are further subdivided into "Excellent", "Good" and "Fair", and the "Unimproved" into "Recurred" and "Not Relieved".

Three factors are taken into consideration in the grouping of the results, — namely, motion, weight-bearing, and pain. Those knees which after the operation have normal motion, or at least seventy degrees of motion, and are able to bear weight and do not give pain, are classified as "Excellent" results. A "Good" result refers to those knees which after operation showed motion of less than seventy degrees, which are able to bear weight, and are practically painless. A "Fair" result denotes stiff or mobile knees unable to bear very much weight, and at times with slight pain, but much better than before operation. The statements of the patients are oftentimes taken into consideration in the grouping of the results, especially in the borderline groups. The results are tabulated in Table II, and need but little comment.

For comparative study, the results of synovectomy from the various clinics reported in the literature during the past ten years are tabulated in Table III.

In looking over the end results of the series presented in this paper in Table II, it will be noted that of the cases listed under "Chronic infectious arthritis" less than two-thirds of the total number synovectomized, or sixty-one and eight-tenths per cent., showed improvement; and a little over one-fourth of the cases, or twenty-six and four-tenths per cent., were not benefited at all by the operation. It must be mentioned at this point, that the two cases eliminated for obvious errors in indications for synovectomy in Dr. Steindler's report in 1925 are also included in these nine cases of "Not relieved". Four cases, or eleven and eight-tenths per cent., in the group of "Unimproved" were temporarily benefited by the operation for a period of eighteen to thirty-three months, before a relapse of the symptoms occurred. About the same percentage of improvement is to be noted under the "Chronic hypertrophic arthritis" of the polyarticular type. In Swett's series of thirty-two cases of chronic infectious arthritis there were seven cases of relapse, and in Speed's series of three cases there were two cases improved. In the present series, by grouping the two arthritic conditions under the polyarticular type together, we have sixty-one and six-tenths

TABLE II

END RESULTS OF THE SYNOVECTOMY

Diagnosis	No. Cases	No. Discard	Improved			Unimproved	
			Excellent	Good	Fair	Recurred	Not Relieved
POLYARTICULAR TYPE							
Chronic infectious arthritis	36	2	2–(5.9%) 18 mos.	9–(26.5%) 46 mos.	10–(29.4%) 35 mos.	4–(11.8%)	9–(26.4%)
Chronic hypertrophic arthritis	5	0		3–(60%) 37 mos.			2–(40%)
MONARTICULAR TYPE							
Chronic hypertrophic arthritis	3	0	2–(66.7%) 47 mos.	1–(33.3%) 22 mos.			
Chronic atrophic arthritis	6	1	2–(40%) 104 mos.		1–(20%) 12 mos.	2–(40%)	
Traumatic arthritis	11	1	6–(60%) 61 mos.	3–(30%) 51 mos.	1–(10%) 48 mos.		
Tuberculous arthritis	3	0					3–(100%)
Syphilitic arthritis	1	1					

NOTE: Figures below the cases and percentages are the average duration of observation in months.

per cent. improved, while the rest were partially relieved, temporarily relieved, or not relieved at all. The percentage in this series is somewhat lower than those reported by Swett and Speed, but in general agrees very well with theirs. Most of Swett's cases showed normal articular cartilage,

TABLE III

RESULTS REPORTED FROM OTHER CLINICS IN THE LITERATURE

	Knees	Results	% Improved	
P. P. Swett[3]				
Chronic infectious arthritis	32	25 without relapse	78.1	32 patients with 32 knees and 6 other joints
E. Jones[6]				
Monarticular arthritis	12	1 case with relapse	91.7	
F. H. Albee[6]				
Tuberculous arthritis	1	Cannot report final result but much better since operation than before.		
Recurrent hydrops	1	Gratifying result		
Others	6			
M. C. Harding[6]				
Chronic arthritis	8–9	First case with most excellent result		
J. S. Speed[5]				
Chronic arthritis (Poly.)	3	1 excellent, 1 improved	66.7	
Chronic arthritis (Mon.)	2	Satisfactory results in both	100	
Traumatic arthritis	2	Satisfactory result	100	
Benign tumor of synovia	2	Satisfactory result	100	
Osteochondromatosis	1	Satisfactory	100	
H. T. Jones[11]				
Chronic synovitis	1	Much better function 2 mos. after operation	100	
N. Allison and G. K. Coonse[12]				
Chronic infectious arthritis	27	95% relieved of pain 75% able to go back to their original work 65% with improvement of health; post-operative motion is not much less than before operation.		
Others	23			
Marinacci[8]				
Pseudolipoma, knee	1	Recovered after resection		
C. H. Heyman[10]	7	6 with normal motion	85.7	
C. Peabody[9]				
Tuberculous arthritis	3	2 fused right away 1 not improved, fusion later		5 cases of TBC 3 knees, 2 elbows
Gibson[4]		Reported very satisfactory results.		
C. Badgley[4]	40	Well pleased with result.		
Sneed[4]		Reported excellent results in syphilis, synovitis, traumatic arthritis, benign tumors of knee, and osteochondromatosis.		

or the cartilage very little damaged; while forty per cent. of the cases reported in this paper under the "Polyarticular Arthritis" showed definite pathology in the joint cartilage in the form of erosion or partial destruction. Three of the four cases reported as "Recurred", and six of the cases listed as "Not relieved" showed definite pathology in the articular cartilage. It would have been desirable, of course, to have had the pathology of the joint confined to the soft tissues only, but this was generally not so with the cases that came under the care of the Department.

The end results of the monarticular type show a higher percentage of improved. Traumatic arthritis heads the list, giving the best results of practically one hundred per cent. improved. Not all, however, obtained good functional motion after the operation, though all of them have good weight-bearing. Of this type of arthritis but one case of the series showed erosion of the articular cartilage. The result was excellent in this instance. Of the two types of chronic arthritis of the monarticular type, there were two cases with a relapse of the former symptoms, one after a good result lasting fifty-seven months and the other with a fair result for seventy-two months after the operation. Ellis Jones reported one case with relapse out of his twelve cases of monarticular arthritis, thus making a percentage of ninety-one and seven-tenths per cent. improved. Speed's series contained two cases of chronic arthritis of the monarticular type and both of them showed satisfactory results. His two cases of traumatic arthritis also showed satisfactory results in both instances. In general, the result in the cases of monarticular arthritis in this series agree very well with those of Jones and Speed.

In this series the tuberculous arthritis cases obtained no relief from synovectomy, and these three cases had the knees fused from one month to fifteen months after the synovectomy. Peabody had somewhat the same experience in one of his cases. Stiles in the discussion of the result of synovectomy of the tuberculous joints says: "In diffuse tuberculous disease of the knee joint, the writer has practically given up all operative procedures which do not aim at producing osseous ankylosis". In cases where the tuberculous process is confined to the synovial membrane, synovectomy may bring the relief of pain, but it is at the expense of the loss of motion. However, the cases seen are rarely of this type.

SUMMARY

1. In well selected cases of chronic arthritis of the polyarticular type about sixty per cent. of the cases are benefited by synovectomy, while in the monarticular type about seventy-five per cent. of the cases are improved by the operation.

2. Traumatic arthritis has a high percentage of good results (ninety-five per cent.) after synovectomy.

3. Tuberculous arthritis of the knee does not obtain relief from synovectomy.

In conclusion it is a pleasant duty to thank Dr. Arthur Steindler for his numerous kindnesses during the prosecution of this study.

REFERENCES

1. Swett, P. P.: Synovectomy in Chronic Infectious Arthritis. J. Bone and Joint Surg., V, 110, Jan. 1923.
2. Synovectomy in Chronic Infectious Arthritis (second paper). J. Bone and Joint Surg., VI, 800, Oct. 1924.
3. Synovectomy in Chronic Infectious Arthritis. Am. J. Surg., XL, 49, 1926.
4. The Present Status of Synovectomy. Am. J. Surg., VI, 807, 1929.
5. Speed, J. S.: Synovectomy of the Knee Joint. J. Am. Med. Assn., LXXXIII, 1814, 1924.
6. Jones, E.: Synovectomy of the Knee Joint in Chronic Arthritis. J. Am. Med. Assn., LXXXI, 1579, 1923.
7. Steindler, A.: Synovectomy and Fat Pad Removal in the Knee. J. Am. Med. Assn., LXXXIV, 16, 1925.
8. Marinacci, S.: (Abstract.) J. Am. Med. Assn., LXXXVII, 1596, 1926.
9. Peabody, C. W.: Chronic Synovial Tuberculosis. Ann. Surg., LXXXVI, 92, 1927.
10. Heyman, C. H.: Synovectomy of the Knee Joint. Surg. Gynec. Obstet., XLVI, 127, 1928.
11. Jones, H. T.: Function of Knee Joint following Synovectomy. Proc. Staff Meetings Mayo Clinic, III, 278, 1928.
12. Allison, N., and Coonse, G. K.: Synovectomy in Chronic Arthritis. Arch. Surg., XVIII, 824, 1929.
13. Campbell, W. C.: In Dean Lewis's Practice of Surgery. Hagerstown, Md., W. F. Prior Co., Vol. II, Chap. 5, p. 223.
14. Burghard, F. F.: Oxford Loose-leaf Surgery. New York, Oxford University Press, II, 62, 1919.
15. Stiles, H. J.: Oxford Loose-leaf Surgery. New York, Oxford University Press, II, 215, 1919.

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THE EFFECT OF LUMBAR SYMPATHECTOMY ON THE GROWTH OF LEGS SHORTENED FROM ANTERIOR POLIOMYELITIS

A Preliminary Report

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Of all the deformities of the lower extremity resulting from infantile paralysis that of shortening, in some respects, is the most serious. Other deformities are amenable to improvement or cure by operation or other orthopaedic measures, but shortening can rarely be overcome. All too frequently the painstaking correction of varus or of valgus and of flexion of the knee and of the hip fail to result in the greatest improvement of function because of shortening of the paralyzed limb. Before the flexion deformities are corrected, the shortening is masked by the more evident distortion at knee and hip. Only when the latter have been corrected does the true amount of shortening become apparent. Too often this proves so great as to mar the otherwise excellent correction of the more evident deformities. Shortening of itself is a considerable handicap to function. It necessitates the use of a raised boot, which besides being unsightly is mechanically a poor piece of apparatus. A foot with weak muscular control is stilted up on two or three inches of cork and this makes balance difficult. No satisfactory measure for the correction of shortening has yet been devised except the operative procedure of Abbott[1]. Abbott's operation is one of magnitude. A simple but equally effective procedure would be very desirable.

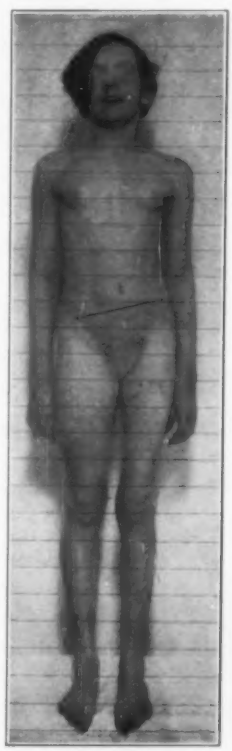

FIG. 1

Overgrowth of left leg resulting from synovial tuberculosis of the left knee of six years' duration. The child was twelve years of age when this photograph was taken, and the left leg was one and one-eighth inches longer than the right.

This and succeeding illustrations are reproduced from photographs of the patients standing behind a screen of threads accurately spaced two inches apart. The black spots on the skin mark the positions of the anterior superior spines. The accurate measurement of small differences in the length of the two legs is difficult. The best index has been found to be the level of the anterior superior spines when the patient is standing erect. For record purposes the above photographic method has proven the most satisfactory. The interspinous line has been drawn on the photographs to accentuate the levels of the spines.

In the search for some means

FIG. 2

Congenital overgrowth of the left leg, the result of an extensive diffuse hemangioma. This boy was born with the left leg larger than the right, both as to length and girth. At birth the increase in length was one-half inch. The disproportion has increased with growth of the child. This photograph was taken when the child was eight years of age. The left leg was then two and one-half inches longer than the right.

FIG. 3

Overgrowth of the left leg, the result of Brodie's abscess in the upper end of the left tibia. At the time the photograph was taken the boy was thirteen years old; the Brodie's abscess had been laid down during an acute attack of osteomyelitis three years previously and had been drained a year later. The left leg was one inch longer than the right.

FIG. 4

Slight overgrowth of left leg due to the presence of a giant-cell tumor in the lower end of the left tibia. At the time the photograph was taken the boy was eight years old and the left leg was one-half inch longer than the right.

to prevent or overcome the short leg which accompanies the paralysis of anterior poliomyelitis, a lead is obtained from certain familiar clinical observations. It is well known, for instance, that synovial tuberculosis of the knee in a child is always accompanied by overgrowth of the affected limb (Fig. 1). Presumably this results from prolonged inflammatory hyperaemia in the knee joint and its vicinity. The neighboring epiphyseal lines of femur and tibia for a prolonged time are supplied with an abnormally great amount of blood, and in consequence are stimulated to

FIG. 5

Overgrowth of left leg resulting from obliterative thrombophlebitis of the long saphenous, femoral, and iliac veins. Following an infection in the calf of the leg, this child developed an extensive thrombophlebitis of the long saphenous, femoral, and iliac veins. The infection subsided but the venous obstruction resulted in marked swelling of the leg. This photograph was taken when the child was seven and one-half years of age and two and one-half years after the onset of the thrombophlebitis. Note the persistent increase in girth of the left leg and the enlarged anastomotic veins over the symphysis pubis. The left leg was one-half inch longer than the right.

FIG. 6

Overgrowth of left leg resulting from recurring hemarthrosis of left knee in a hemophilic patient. This photograph was taken when the child was eleven years of age and one and one-half years after the first hemorrhage into the knee joint. The left leg was one inch longer than the right.

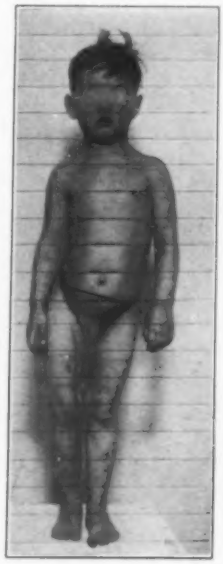

FIG. 7

Overgrowth of right leg resulting from chronic osteomyelitis of right femur. At the time this photograph was taken the child was four years of age; the acute onset of the osteomyelitis had occurred two and one-half years previously, and the right leg was one inch longer than the left.

increased growth. As long as the disease remains confined chiefly to the synovial membrane, the tendency to overgrowth is not counteracted by the destructive shortening which takes place when cartilage and bone are destroyed. Careful search will reveal many pathologic conditions besides synovial tuberculosis of the knee, which, in children, cause increased growth of the affected limb. In a comparatively short time the writer has been able to collect many such instances due to such varied conditions as: *a*. hemangioma of the leg (Fig. 2); *b*. Brodie's abscess of the upper end of the tibia (Fig. 3); *c*. giant-cell tumor of the lower end of the tibia (Fig. 4); *d*. femoral and iliac thrombosis (Fig. 5); *e*. recurring hemarthrosis of the

FIG. 8

Overgrowth of left leg following a severe laceration of the soft tissues of the leg, the healing of which was complicated by infection and prolonged ulceration. At the time this photograph was taken the boy was eight years of age; the accident had occurred three years previously; the wound had been healed for two years, and the leg was seven-eighths of an inch longer than the right.

knee due to hemophilia (Fig. 6); *f*. chronic osteomyelitis of the femur (Fig. 7); *g*. severe trauma of the soft tissues of the leg with prolonged infection and ulceration (Fig. 8); and *h*. fracture of the femur (Fig. 9).

All these varied conditions which give rise to increased growth of the diseased leg share the common factor of increased blood supply. Usually it is an active and inflammatory hyperaemia, but occasionally, as in the cases of venous thrombosis, the hyperaemia is passive. It seems reasonable to suppose that if, in a child, hyperaemia involving one lower extremity could be produced and sustained, it would result in more rapid growth of that limb than its fellow.

FIG. 9

Overgrowth of right leg following fracture of the right femur. The fracture was simple fracture of the middle of the femur, nearly exactly transverse. It was treated by extension and a Thomas splint. Two years later when this photograph was taken, at eight years of age, the right leg was one and one-quarter inches longer than the left.

Assuming that increased blood supply to the leg will result in increased growth of the limb, the problem of correcting the short leg due to infantile paralysis resolves itself into finding a simple and effective means of increasing the blood supply to one leg. The required hyperaemia might be obtained by the operation of lumbar ramisection or sympathectomy; since these result in prolonged, perhaps permanent, dilatation of the blood vessels of the lower extremity. This conception seemed to have sufficient possibilities to render it worthy of investigation. The present report is concerned with the result which followed the performance of the procedure upon a suitable patient.

There are certain aspects of the problem which do not lend themselves to animal experimentation. Chief of these is the question whether destruction of the anterior horn cells in the lower dorsal and lumbar segments of

FIG. 10-A

Photographs of L. G. before and after the operation of left lumbar sympathectomy. Fig. 10-A. On April 20, 1928, immediately before operation. At this date the left leg was one and one-half inches shorter than the right.

Fig. 10-B. On April 16, 1930, two years after operation. On this date the left leg was slightly less than an inch shorter than the right. Note the diminished tilt of the pelvis resulting from diminished shortening of the left leg.

FIG. 10-B

FIG. 11-A

Photographs of L. G. before and after operation. Fig. 11-A. On April 20, 1928; the shortening of the left leg has been compensated for by a block one and one-half inches thick.

Fig. 11-B. On April 16, 1930; the left leg is supported by the same block. Note that block which before operation did not quite compensate for the shortening now raises the left side of the pelvis above the right, the result of diminished shortening of the left leg.

FIG. 11-B

the cord by the virus of anterior poliomyelitis does not also result in destruction of, or damage to, the closely related cells which give rise to the sympathetic outflow. True, the cold, blue, clammy foot of anterior poliomyelitis is the opposite of that which occurs in sympathetic paralysis. Yet if it were true that anterior poliomyelitis often, or even sometimes, leads to destruction of the sympathetic centers, it would render sympathectomy useless. After much thought and discussion, it seemed clear that an answer to this question could only be obtained by performing the operation upon a suitable patient.

L. G., age ten years, the first patient operated upon, was an ideal case, since the sole deformity remaining from her attack of poliomyelitis was one and a half inches of shortening. Eight years previously, at the age of two years, she had suffered an attack of infantile paralysis, involving chiefly the left leg. During the acute stage the left leg had been completely paralyzed, but later recovery to some degree had occurred in all the muscles formerly paralyzed. Power was subnormal, particularly in the muscles below the knee, but no serious imbalance existed between muscle groups; consequently no deformity had arisen. The leg was atrophic and one and a half inches shorter than its fellow. This degree of shortening was sufficient to cause a noticeable limp, and the question of a raise on the boot had been considered. The foot was cold, blue, and moist. In the winter she had much trouble from coldness of the foot. The operation and its possibilities were discussed with the parents. They gave their consent to its trial. Accordingly, a left lumbar sympathectomy was performed on April 25, 1928. This was followed at once by increased warmth and dryness of the foot, which has been maintained constantly since (Table I). Sometimes the increase in skin temperature of the left foot over the right was as much as ten degrees, centigrade;

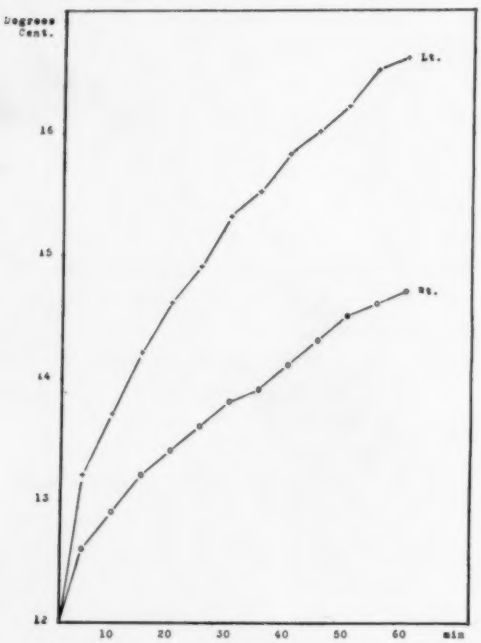

FIG. 12

L. G. Graph of the calorimetric measurement of the heat output of both feet on April 15, 1930, two years after operation. The feet were each immersed in a tank containing 7100 c.c. of water at 12 degrees, C. The rise in temperature was recorded at five-minute periods for an hour. Note that the left foot has raised the temperature of the water through nearly twice as many degrees of temperature as has the right. The heat output of the left foot over that of the right is equivalent to 13,500 small calories.

While there is no satisfactorily accurate means of measuring the circulation of an extremity, the calorimetric method may be taken as indicating approximately the comparative flow through two similar limbs compared at the same time under similar circumstances.

once it was fifteen degrees, centigrade. This is dependent not upon variations in the temperature of the left foot, but in depression of the temperature of the right foot from external cold. The temperature of the left foot remains relatively constant at a high level. It is of interest to record that both the patient and her parents feel that the relief from the discomfort of the cold foot in winter has been quite sufficient to justify the operation.

The great interest in this case, however, lies in the fact that there has been a definite increase in the rate of growth of this limb (Table I). During the two years which have elapsed since the operation was performed, the difference in length between the two limbs, instead of increasing, has diminished from one and a half inches to slightly less than one inch. This is best illustrated by the series of photographs (Figs. 10-A, 10-B, 11-A and 11-B). Coincident with this change in length, there has been an improvement in function. Her limp is now scarcely perceptible and a raised boot is not used.

It might be questioned whether increase in the skin temperature of the foot is a true index of increased blood supply to the limb. It is conceivable that section of the sympathetic nerves to the lower extremity might result in dilatation of the vessels in the skin, without causing any important increase in the blood supply to the limb as a whole. The increased rate of growth obtained in the case herein reported would indicate that lumbar sympathectomy does cause increase in the blood supply to the lower limb. In addition, the calorimetric readings recorded in Figure 12 support the same conclusion. From this diagram it will be seen that the output of heat from the left foot was considerably greater than that from the right.

The result obtained in this case seems of sufficient importance to place it on record. Several other carefully selected patients have now been treated similarly. It is too early as yet to draw any conclusions from these more recent cases. They will be reported upon later. In the meantime, animal experiments are being performed, designed to illustrate the effect of lumbar sympathectomy upon the rate of growth of the lower extremity. Since the clinical observations in cases of iliac and femoral thrombosis seemed to indicate that passive hyperaemia also caused increased rate of growth of the limb, certain of the animal sympathectomies have been combined with venous ligations. The experimental observations will also be reported upon later.

TABLE I

	Right	*Left*	*Shortening*
June 25, 1928	32. degrees, C.	34.5 degrees, C.	1½ inches +
July 16, 1928	29.5 "	34.5 "	
Nov. 1, 1928	27. "	35. "	
Nov. 28, 1928	25.5 "	35.5 "	
Feb. 25, 1929	26. "	34. "	
March 14, 1929	26. "	34. "	1¼ inches
June 27, 1929	27.5 "	33. "	1⅛ inches
Oct. 12, 1929	24. "	34. "	1⅛ inches
Dec. 12, 1929	19. "	34. "	1 inch
April 15, 1930	24. "	33. "	1 inch −

Record of the skin temperature of the soles of the feet at various periods following the operation of left lumbar sympathectomy (performed April 25, 1928). The fourth column records the decreasing shortness of the left leg.

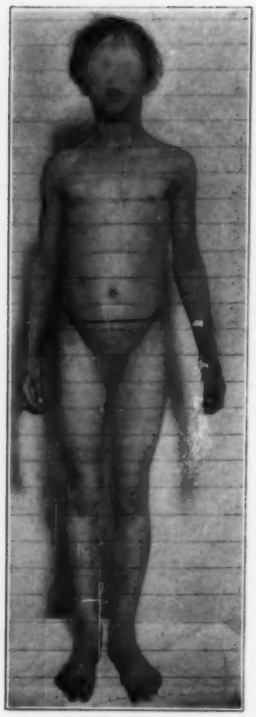

FIG. 13

Overgrowth of left leg seven months after left lumbar sympathectomy for the cure of Hirschsprung's disease. At the time of the operation the legs were equal in length and normal in every respect. When the photograph was taken the left leg was slightly longer than the right (one-quarter inch). Age nine years.

Since the work of Hunter and Royle, the operations of ramisection and sympathectomy have been performed many times upon children. It might be thought that examination of those children upon whom the unilateral operation had been performed would confirm the influence of lumbar ramisection upon the growth of the lower extremities. The author has examined all such patients who have been operated upon in the Hospital for Sick Children without gaining any definite information. These patients were all suffering from spastic paralysis. Upon most of them the bilateral operation was performed; therefore, no conclusions can be drawn. Only two patients have been found upon whom the unilateral operation was performed. Both of these were suffering from spastic hemiplegia. In neither was there any pre-operative measurement of the length of the legs, so that no basis of comparison exists.

However, a case of sympathectomy, more recent than the spastic paralysis group, does provide confirmatory evidence. This was a child of nine years upon whom the operation of left sympathectomy was performed for Hirschsprung's disease by Dr. D. E. Robertson in September 1929. In addition to curing the megacolon, the operation produced the usual vascular changes in the left leg. In November 1929, the legs were of the same length and the left foot much hotter than the right. In April 1930 the left foot was still warmer than the right and already one-quarter of an inch longer (Fig. 13).

CONCLUSIONS

1. Lumbar sympathectomy performed upon patients suffering from paralysis of the leg due to anterior poliomyelitis produces the same vascular changes that have been observed in normal patients,—*viz.*, increased warmth and dryness of the foot due to vasodilatation and to paralysis of the sweat glands. The calorimetric readings indicate that sympathectomy causes considerable increase in the blood supply to the foot.

2. The vascular changes are of prolonged duration and perhaps are permanent.

3. It is possible to accelerate the rate of growth of a child's leg by the operation of lumbar sympathectomy.

4. The increase in comfort which results from transforming the cold, blue, damp foot of anterior poliomyelitis to one which is warm and dry is much appreciated by the patient.

1. ABBOTT, L. C.: The Operative Lengthening of the Tibia and Fibula. J. Bone and Joint Surg., IX, 128, Jan. 1927.

SYNOVIAL CELLS IN JOINT EFFUSIONS*

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The cells in inflammatory joint effusions are derived either from the circulation or from the synovial tissue. The identification of the various elements is not a simple matter. Polynuclear leucocytes and lymphocytes preserve usually their morphologic properties and are therefore recognized in stained specimens. On the other hand it is often difficult to decide whether a large mononuclear cell should be classed as a macrophage, a clasmatocyte from the circulation, or an element derived from the lining synovial membrane.

Some investigators have employed supervital staining processes for the determination of the cytology of inflammatory joint effusions. But these methods require special training, apparatus, and prolonged observation; the examination of the fluids has to be carried out immediately after aspiration; this also is not always feasible. For these reasons in clinical work we still depend on specimens prepared with one of the routinely employed blood stains.

For the study of the characteristics of synovial cells in these routine slides, we have employed the following method. The synovial fluids are centrifuged and the sediment spread on clean slides and dried. In every case where a synovectomy is performed, a piece of the synovial membrane is washed in normal saline solution and the superficial layers scraped with a scalpel. The scrapings are spread on slides and dried. Both the sediment from the synovial fluid and the scrapings from the membrane are stained in identical manner with Wright's blood stain. By comparing the cells from the scrapings we can then identify the synovial cells in the fluid of the joint effusions.

FIG. 1

The photographs will illustrate this method. Figure 1 shows the synovial membrane from a case of villous synovitis of the knee. Figure 2 shows the sediment of the effusion aspirated from the knee

*From the services of Dr. Harry Finkelstein and Dr. Samuel Kleinberg.

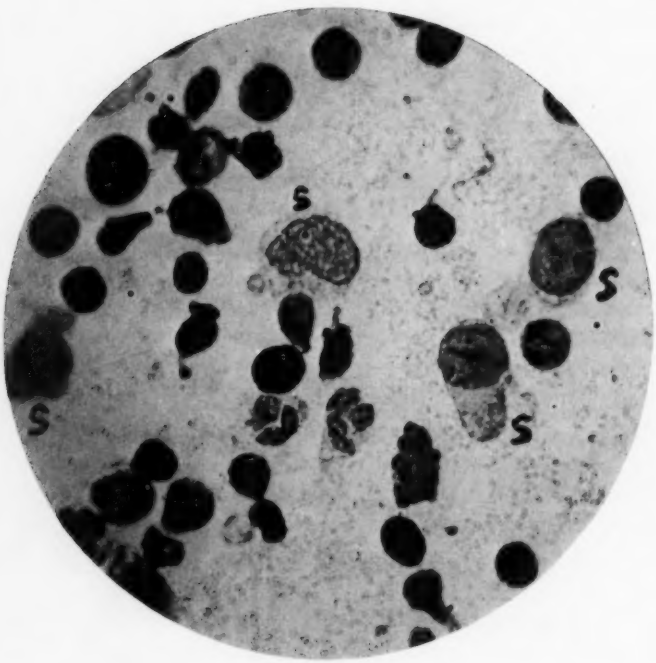

FIG. 2

joint one day before operation. The differential cell count was: small lymphocytes forty per cent.; mononuclear cells twenty-five per cent.; polynuclear leucocytes five per cent.; the remaining thirty per cent. were made up by large cells, which are identical with the cells seen in Figure 3 from the scrapings of the inner layers of the synovial membrane. These cells are from forty to sixty microns in size, polygonal; some have processes. The cytoplasm is only faintly stained; it is basophilic, homogeneous, and contains eventually a vacuole. The nucleus is large (15 to 20 microns), mostly oval, sometimes indented on one side; very rarely round. It is eccentrically situated and frequently touches or crosses the border of the cytoplasm, thus giving the impression of a seal ring. Very characteristic is the heavy stained periphery. The nucleoreticulum forms a meshwork of fine and coarse granules. An eccentric nucleolus is seen very often; likewise a vacuole. Some cells contain two nuclei.

The study of the characteristic appearance of the synovial cells in the scrapings makes it possible to identify these cells in stained specimens of synovial fluids. The macrophage of the blood and the clasmatocyte are usually smaller (from 15 to 30 microns). The cytoplasm is more heavily stained. The nuclei also take the dye more uniformly and do not show a reticulum with Wright stain. They are situated quite concentrically in the macrophage, and while eccentrically in the clasmatocytes, yet do not touch the periphery of the cytoplasm.

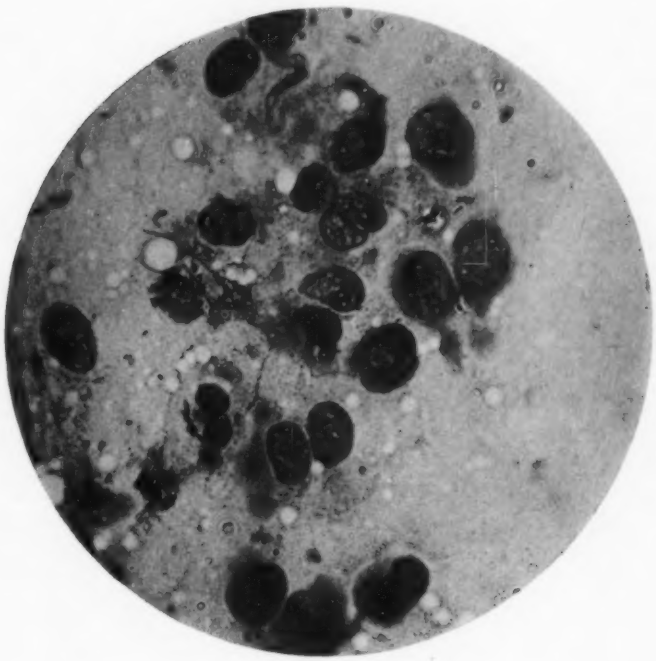

FIG. 3

CLINICAL CONSIDERATION

Normal joints contain only a small amount of colloidal fluid in which few cells are suspended. We found ten to fifty cells per cubic centimeter in normal knee joints of amputated limbs. About ninety-five per cent. were synovial cells; the remaining five per cent. were small lymphocytes; only occasionally a polynuclear leucocyte was seen. No red blood corpuscles were found.

In effusions there is an increase of fluid, either alone or combined with an increase in the number of cells. The first is the case in transudates, the second in exudates.

The conclusion as to the character of the inflammation is usually based on the prevalence of either leucocytes or lymphocytes. We wish to call attention to the significance of the synovial cells in the fluid.

The increase in polynuclear leucocytes is recognized as characteristic for an acute inflammation or for an exacerbation of a chronic process. This is the case in rheumatic fever, septic and infectious arthritis, and during an acute involvement of joints in chronic arthritis. The number of lymphocytes is increased in chronic inflammatory processes of specific or non-specific origin (tuberculous synovitis, syphylitic arthritis, osteo-arthritis).

While lymphocytes and leucocytes express the circulatory reaction, the synovial cells are apt to indicate the local change which takes place

during the inflammatory process in the synovial tissue. In our experience, an effusion containing over fifteen per cent. of synovial cells signifies proliferative changes; an increase to twenty-five per cent. is suggestive of a villous degeneration of the synovial membrane. The increase in the synovial cells is usually found to be combined with mononuclear elements. In acute processes where the exudate contains chiefly polynuclear leucocytes we found only few synovial cells. In these cases the general exudative reaction prevails over the local proliferation of the synovial tissue.

SUMMARY

(1) By comparing scrapings from the synovial membrane with routinely stained sediment from joint effusions, we are able to identify the synovial cells.

(2) A relative increase of synovial cells appears to signify proliferative and villous changes of the synovial membranes.

(3) This finding is, therefore, of practical value in all cases where the condition of the synovial membrane has to be determined to decide our therapeutic and operative procedure. The information derived from the differential count of the synovial cells can be used to advantage in selecting cases which may be benefited by synovectomy.

THE SURGICAL TREATMENT OF CONGENITAL ANTERIOR DISLOCATION OF THE KNEE*†

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The infrequence of congenital dislocation of the knee is illustrated by the occurrence of only four such cases in my thirty years of active orthopaedic practice. One was a bilateral case with flexion deformities, a report of which was published in Russian.

Three cases were associated with extension contractures. The first one[1] was a baby girl fifteen months old. The knees were hyperextended, and the patellae apparently absent. The feet were in calcaneovalgus. The operative treatment consisted in displacing the insertion of the patellar tendons proximally as well as in restoring the patellae.

The second case was that of a new-born girl whose feet were pressed against the shoulders. The knees could be forcefully straightened, but only after the subcutaneous division of the tense iliotibial bands could the tibial heads be prevented from snapping back into the faulty position. Plaster was applied with the knees flexed. When the casts were removed after ten days, free movement was possible. The child then disappeared and could not be examined further.

The third case, which prompted the publication of this article, was that of a nine-year-old boy. His mother stated that he had been born with the knees hyperextended and pressed against the chest. Soon after birth the lower extremities had been straightened and placed in casts. The child did not walk alone until the third year, and not until then could the knee caps be felt.

When first seen by us, he was a thin, pale weakling with the heart enlarged to the left, and a blowing systolic murmur over the aorta. Physical examination was otherwise negative, except for the deformities of the right lower extremity. On examination it was observed at once that the right lower extremity was considerably shorter than the left and atrophic. The child stood on the left foot. The right was in extreme equinus, and the right knee in outward rotation. The usual prominence of the patella was almost entirely absent from the front of the knee. Proximal to the knee was a saddle-shaped depression and the quadriceps was poorly defined. At Scarpa's triangle was a depression bounded above by the anterior-superior iliac spine and Poupart's ligament. The right anterior-superior spine was seven centimeters lower than the left. In the right popliteal space were two ball-like projections with a hollow between them. Flexion on the right was possible to 135 degrees, and hyperextension, until the knee was almost doubled up. Measurements were:

	Right	*Left*
Femur	31 centimeters	34 centimeters
Tibia	29 centimeters	32 centimeters

The right greater trochanter was five centimeters above the Roser-Nélaton line. There was a right total scoliosis. The right femoral head could not be palpated under the femoral artery (congenital dislocation). When examined under light anaesthesia the flail right knee lacked the normal stability and could be bent into knock-knee or bow-leg, flexed to a right angle, or hyperextended into extreme recurvatum.

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†Translated from the German and arranged by Dr. Walter P. Blount, Milwaukee, Wisconsin.

FIG. 1

X-ray showed a congenital dislocation of the right hip with the femoral head riding high above the normal position in a false acetabulum. The acetabulum was shallow, the head poorly developed, and the neck showed a coxa vara. In the right knee, the two joint surfaces were overriding with the femoral condyles posterior and distal, and the tibial head anterior and proximal, so that the epiphyseal lines were on the same level (Fig. 1). The head of the tibia was essentially normal in shape, but the femur was strikingly altered. Instead of slanting posteriorly, as is usual, the femoral condyles were in line with the shaft. On their anterior surface was a sharply defined depression suggesting an erosion by the tibial head.

On July 12, 1927, under light chloroform anaesthesia and a tourniquet, the right knee joint was explored through a curved twenty-centimeter anterolateral incision. The tibial tubercle was chiseled off, and the patella and its tendon turned proximally. The iliotibial band was divided three to four centimeters above the joint line and freed from the adjacent muscles. By powerful traction the articular surface of the tibia was brought down to the normal level, but because of distortion of the joint surfaces, could not be maintained in position even after division of the tense cruciate ligaments. To improve the contact, several thin transverse slices were removed from under the cartilage of the tibial head, until the joint surfaces could be well approximated. The patellar ligament was then too short, so the tibial tubercle was freed from its periosteum and the latter sewed to the tibia three centimeters proximal to its former position. The wound was closed and a cast applied with the knee in extension.

Examination on November 18, 1927, showed a recurrence of the deformity, with about thirty degrees of active motion at the knee. On November 22, 1927, under anaesthesia, reduction was again accomplished and the knee fixed in plaster at a right angle. The foot became cyanotic, however, and after two hours the cast was split anteriorly. After three days the cast was removed on account of pain and a splint applied with the knee in flexion. The boy walked with one crutch.

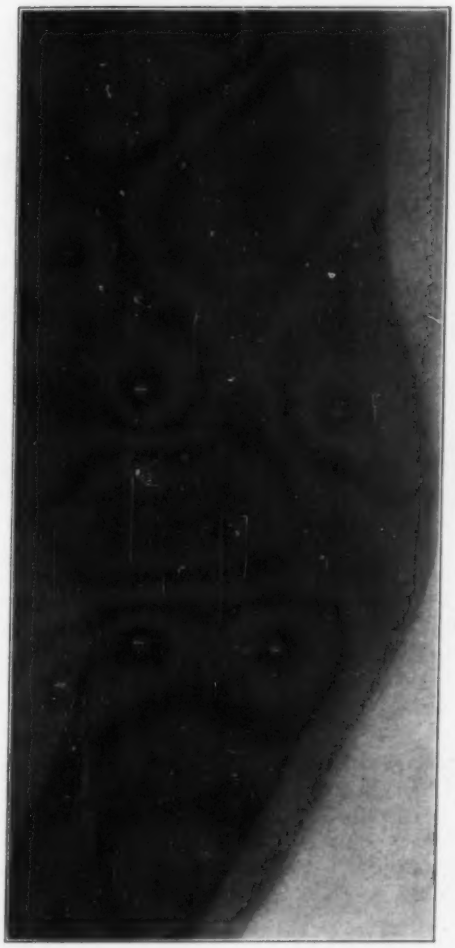

FIG. 2

FIG. 3

For the sake of clearness, the cartilage flap is shown somewhat too thick. In reality only the cartilaginous covering is raised.

FIG. 4

On January 15, 1929, a lateral x-ray of the right knee (Fig. 2) showed the femoral condyles impinging on the posterior rim of the tibial head. The epiphyseal lines were no longer at the same level; that of the tibia had been displaced at least three centimeters distally. The anterior aspect of the femoral condyles was no longer depressed, but flat. The posterior margin of the tibial head appeared as though planed off.

On January 19, 1929, another operation was performed under ether anaesthesia and a tourniquet. The right knee joint was exposed through a twelve-centimeter longitudinal incision, two centimeters lateral to the patella. The iliotibial band was severed. The rectus femoris was divided three centimeters proximal to the patella, and the latter turned distally. With the joint exposed, it was possible to reduce the dislocation by traction and manipulation. In order to secure the position and prevent the displacement of the tibia forward, a block was formed. A flap of cartilage was cut from both femoral condyles (Fig. 3) and tilted forward (Fig. 4) to produce a convexity on the anterior aspect of the condyles. The cartilage covering the posterior surface of the tibial head was then shaved off with a knife, and the remnants of the cruciate ligaments removed. The capsule, rectus femoris, and skin were sutured and plaster applied with the knee in extension. The patient made an uneventful recovery.

FIG. 5

The boy was examined on February 15, 1930. He walked well without crutch or cane, with the limp usual to a congenital dislocation of the hip. The right knee was fully extended, and ten degrees of active flexion was possible. Anteriorly one could see and palpate the bony block (Fig. 5). Treatment of the right hip was left for the summer.

In the three cases seen, the deformity was bilateral and confirmed the predominance among females (Wehsarg[2]). The dislocations were not the result of contractures but were true malformations (Drehmann[3]) as shown particularly by the associated deformities in Cases 1 and 3. Case 2 was too young to demonstrate a possible hip abnormality. The question raised by Kopits[4] as to whether the condition is a congenital dislocation or subluxation seems unimportant, as the former is but an exaggerated form of the latter. In the literature the longitudinal displacement is described only in the older advanced cases, and not in children under two and one-half months (Mayer[5]). In all cases, the femoral condyles are to be felt free in the popliteal space. The erosion of the anterior aspect of the femoral condyles can be well seen in the schematic drawing of Wolff[6] as well as in the x-rays of Kopits[4] and McFarland[7]. The posterior aspect of the tibial head is shown by Kopits as though ground away, leaving a bracket-like projection.

All writers agree that the treatment should be started immediately after birth. Kirsten[8] has shown that even after a few weeks, many cases are irreducible by gentle bloodless methods. We required open operation in the second case. Subcutaneous division of the iliotibial bands was

immediately effective in allowing reduction. In older children division of the iliotibial band alone is not sufficient. Other obstacles to reduction are present. The lateral ligaments and patellar ligament have contracted. The rectus femoris itself is not shortened but relaxed (Reiner[9] and Bacilieri[10]), while the patellar ligament is tightly stretched and fixed in its abnormal position. Without removing these obstacles, reduction cannot be accomplished. Compared to lengthening the patellar tendon, as advocated by Mayer and Kopits, or division of the central portion of the quadriceps tendon, we consider our method easier and less disturbing to the normal relations. In two cases (1 and 3) we transplanted the insertion of the patellar tendon proximally without weakening it (Wolff), and this with division of the iliotibial band was sufficient to allow and maintain reduction. In Case 3, as in cases of McFarland, Kopits, and others, the complicating changes in the shape of the articular surfaces was the factor which prevented fixation in the desired position. To control this, most writers resort to variously constructed braces and apparatus provided with straps and elastics. Reiner, Bacilieri, and others undertook the deepening of the abnormally convex facets of the tibia so that they would hold the femoral condyles. Other surgeons arthrodesed the joints, particularly in adults. We would propose a simple and effective method in the broadening of the articular surface of the femur. The depression of the anterior surface was filled out by raising flaps of cartilage. They proved to be somewhat too long so as to interfere with movement of the joint, but the idea was correct. The need of appliances was eliminated by the tension of the soft tissues about the joint which kept the joint surfaces closely approximated.

REFERENCES

1. Kofman, S.: Ein Fall von angeborener Kniegelenksluxation mit Fehlen der Patella. Operative Herstellung der Kniescheibe. Arch. f. Orthop. u. Unfall-Chir., VI, 41, 1907–1908.
2. Wehsarg, R.: Über die Kongenitale Subluxation des Kniegelenkes. Arch. f. Orthop. u. Unfall-Chir., III, 196, 1905.
3. Drehmann, G.: Die congenitalen Luxationen des Kniegelenks. Ztschr. f. Orthop. Chir., VII, 459, 1900.
4. Kopits, E.: Beiträge zur Pathologie und Therapie der angeborenen Kniegelenkssubluxationen. Arch. f. Orthop. u. Unfall-Chir., XXIII, 593, 1924–1925.
5. Mayer, L.: Congenital Anterior Subluxation of the Knee. Am. J. Orthop. Surg., X, 411, Feb. 1913.
6. Wolff, J.: Über einen Fall von "willkürlicher" angeborener präfemorales Kniegelenksluxationen nebst anderweitigen angeborenen Anomalieen fast sämmtlicher Gelenke des Körpers. Ztschr. f. Orthop. Chir., II, 23, 1893.
7. McFarland, B. L.: Congenital Dislocation of the Knee. J. Bone and Joint Surg., XI, 281, Apr. 1929.
8. Kirsten: Säugling mit doppelseitiger, angeborener totaler vorderer Kniegelenksluxation. Nürnberger med. Gesellsch. in Münchener med. Wchnschr., LXXII, 789, May 8, 1925.
9. Reiner, M.: Über einen blutig reponirten Fall von angeborener Kniegelenksluxation. Ztschr. f. Orthop. Chir., XIII, 442, 1904.
10. Bacilieri, L.: Über kongenitale Luxationen im Kniegelenk. Arch. f. Orthop. u. Unfall-Chir., III, 213, 1905.

SO CALLED RENAL RICKETS: REPORT OF A CASE*†

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The term renal rickets has been given to a disease entity characterized by renal insufficiency, due usually to chronic interstitial nephritis, as evidenced by albuminuria, high concentration of blood urea, and so forth, and associated with deformities of the bones resembling rickets, such as knock-knee, beading of the ribs, and widening of the epiphyses.

REPORT OF CASE

A boy, aged eighteen years, came to the clinic June 4, 1929, with the chief complaint of inability to walk. His family history and past history were negative except for one significant fact. This was that at the age of six years, in 1917, he had been brought to the clinic complaining of a series of attacks of pain in the right side of the abdomen, associated with nausea, vomiting, chills, and fever. The attacks had first come on one year previously and had recurred every three or four weeks for a time. They had cleared up during the summer but had come on again in the fall. He had been obliged to urinate once each night, and three to six times in the daytime. No dysuria or hematuria had been present. It was noted that during these attacks he urinated every thirty to forty minutes and had slight pain at these times. General examination revealed that the boy was undernourished, looked pale, and that there was slight tenderness to palpation in the right lower quadrant of the abdomen. In three specimens of urine the presence of albumin was graded 0, 1, and 2. Erythrocytes and pus cells were present. Studies of the blood, including the Wassermann reaction, gave negative results. Escherichia coli were grown in cultures of the urine. A roentgenogram of the kidneys, ureters, and bladder gave negative results, and the return of phenolsulphonephthalein from both kidneys taken together was fifty per cent. in two hours and fifteen minutes. A diagnosis of hydronephrosis of the right kidney, with infection, was made, and operation was performed by W. J. Mayo, February 3, 1917. The operative note stated that the right kidney was removed because of intermittent hydronephrosis due to anomalous blood vessels coming from in front, passing to the lower pole in the sinus of the kidney, causing marked kinking of the ureter. The left kidney was examined by hand and was found to be normal. The appendix was removed because it had been handled in the course of the operation, and the stomach, duodenum, and gallbladder were found to be normal. The pathologic report concerning the kidney was that the condition was one of hydronephrosis with infection, with diffuse chronic nephritis involving the glomeruli, tubules, and interstitial tissue. The boy made a good recovery, marred only by the development of acute otitis media of the left side, which cleared up without trouble.

When the patient returned to the clinic in 1929, he said that he had been well, had had no abdominal distress, and had led an active life until the fall of 1926, when, at the age of fifteen years he had begun to have pains in the back when he ran. Some time after this he noticed that he could not run as well as usual because of pain in the back and weakness. Shortly afterward he found he could not run at all but could walk all right. Then his walking became impaired, so that since Christmas, 1928, he had used

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crutches. He noticed that he had grown shorter in stature. This had been going on over a period of one and a half years. He also noticed that his teeth had grown wider apart. For one and a half to two years he had been having peculiar attacks of chills, accompanied by his feeling cold all over. He did not have fever or nausea at these times. The attacks lasted overnight and had been coming with regularity during the three to four months immediately preceding his visit to the clinic. He said that he had had a feeling in the first two fingers of the left hand as if no muscles were present. The muscles of the back and legs were hypersensitive. He urinated two to three times at night and four to five times in the daytime. There was no pain, hematuria, or dysuria. The urine was said to have been cloudy and to have given a white deposit for a year or more. He had had some sort of visual disturbance once, when objects seemed to move up and down before his eyes, but this had not been repeated.

On general examination he presented a bizarre picture. He was four feet, four inches in height; but he had been four feet, eleven and one-half inches in height three years previously. He weighed sixty-eight pounds; but he had weighed as much as ninety-four pounds. His skin was dry, wrinkled, and yellow; and he looked like a little old man. There was marked bowing laterally of the long bones, particularly of the femora. The tibiae were sharp and the legs were angulated outward at the knee. Hyperflexion of the hips was possible; adduction was better than normal, but abduction and extension of the hips were limited. The humerus of each arm was convex anteriorly

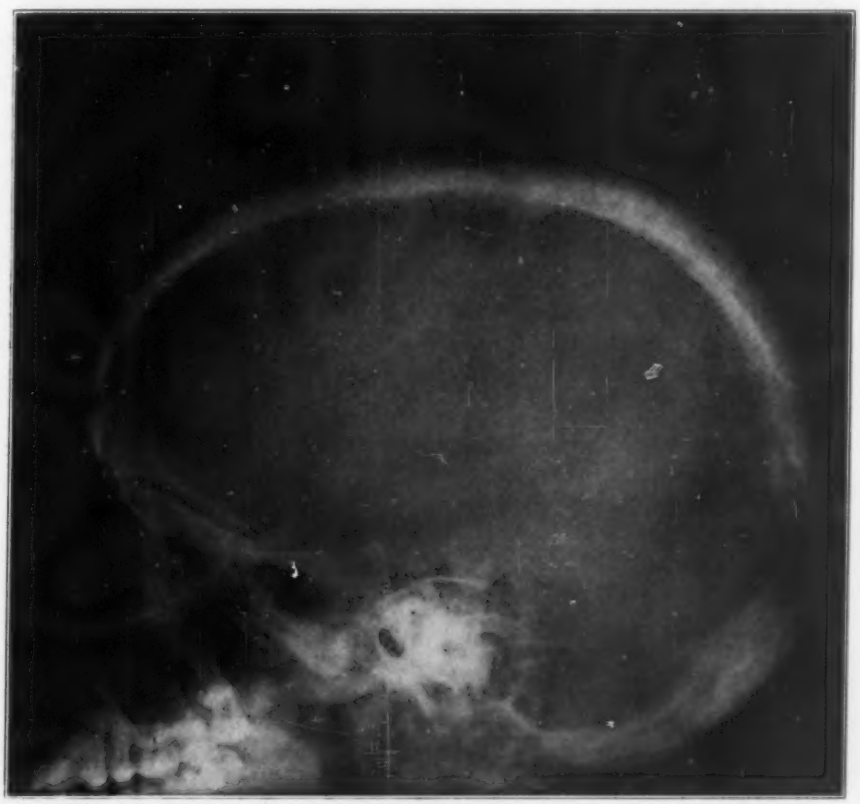

FIG. 1

Thickening and fuzzy appearance of the bones of the skull similar to that found in Paget's disease.

FIG. 2

Widening, thinning, and cupping of vertebrae with increase in size of intervertebral spaces.

and the ulna and radius were laterally bowed. The patient could flex his elbow to ninety degrees only and he could not make a fist. There was tenderness over the thoracic portion of the spinal column and limitation of all motion, particularly in the cervical region. The ribs were sharply angulated at the nipple line. The feet were in abduction. There was marked atrophy of all the muscles, and the patient walked with great difficulty, with his hands on his knees. His teeth were short and narrow, and the spaces between them were unusually broad. The tonsils were cryptic, and a faint, precordial, systolic murmur was present, with slight irregularity of the cardiac rate. The abdomen was negative to examination except for the operative scar. The reflexes were hyperactive.

Urinalysis on two occasions revealed albumin, graded 2, pus cells graded 3 and 2, and occasional erythrocytes. The concentration of blood urea was 218 milligrams in each 100 cubic centimeters. A culture of urine resulted in growth of gram-negative bacilli. The concentration of serum calcium was nine and two-tenths milligrams, and of

serum phosphorus, six and one-tenth milligrams in each 100 cubic centimeters. The concentration of hemoglobin was sixty per cent. (Dare); erythrocytes numbered 3,860,000, and leucocytes 7,000 in each cubic millimeter of blood; the color index was seven-tenths plus. The Wassermann reaction was again negative. Blood pressures were 128 systolic and 90 diastolic, measured in millimeters of mercury; the pulse rate was 112 beats each minute, and the temperature, 98.4 degrees.

Roentgenograms revealed a generalized process involving all the bones, characterized by atrophy, softening, and thickening of the epiphyseal lines. There was diffuse, homogenous thickening of the skull, with a finely irregular, fuzzy appearance similar to that seen in Paget's disease (Fig. 1). The vertebrae were markedly flattened and widened, and there was cupping of the superior and inferior surfaces. The intervertebral spaces were much wider than those normally found (Fig. 2). There was bowing of all the long bones of both arms, with definite thickening of the periosteum. The pelvic bones were greatly distorted. The iliac crests were markedly thickened and the shape

FIG. 3

Massive deformity of the pelvis with generalized thickening, softening, and bilateral coxa vara.

of the bones was as though some great force had pushed the pelvis in from both sides. Coxa vara was present and the femora were laterally bowed (Fig. 3). Here, also, the periosteum was thickened and lifted up. The thorax was distorted, and the ribs were close together. The roentgenographic appearance of the epiphyseal lines was best seen at the knees. There seemed to be increased deposition of calcium on the diaphyseal side of the epiphyseal line, which was definite and heavy, although slightly irregular. The appearance was markedly different from the irregular ossification, and the woolly characteristics seen in true infantile rickets. There was no widening of the epiphysis here, such as there is in rickets. There seemed to be a definite space between the diaphysis and the epiphysis (Fig. 4). There was no suggestion of the "rotting-post" appearance which has been described as being typical of rickets. In addition, there was seen in all the bones a general, hazy mottling, with irregularly spotted, snow-flake-like areas in the heads of the femur and humerus on both sides. The clear normal outlines of the bones were missing. There was thickening of both periosteum and cortex, and in places the cortex and medulla were not differentiated. The most important points noted, then, were as follows: Atrophy and softening of bone; increased, irregular calcification at the epiphyseal lines, thickening and elevation of the periosteum, thickening of the cortex, and a general, hazy, porotic appearance.

A diagnosis of pyelonephritis, associated with bony deformity, the whole condition resembling renal rickets, was made. Because of the severe renal insufficiency, general

FIG. 4

Heavy irregular deposit of calcium on the diaphyseal side of the epiphyseal lines at the knees. Genu valgum is also present.

measures,—such as administration of cod-liver oil, sun baths, and so forth,—were advised. The patient returned home, and in a recent communication it was learned that although he had been fairly well all summer, he had failed rapidly in the autumn, and that after suffering severe pain for several days and being unable to excrete any urine, he died October 1, 1929, four months after he came to the clinic. The death was apparently caused by uraemia. Necropsy was not obtained.

REPORTS IN THE LITERATURE

In a review of the literature it was found that although renal rickets was not adequately described until 1911, Lucas, in 1883, thought that the association of albuminuria with late rickets was not merely accidental. Fletcher, in 1911, was the first man clearly to correlate the finding of rachitic deformities with that of chronic interstitial nephritis. He cited the case of a boy, aged six years, who was said not to have grown since the end of his first year. He had polyuria, polydipsia, and caries of the teeth; and genu valgum appeared in his fifth year. The specific gravity of the urine was 1.005, and albumin and granular casts occasionally were found. Thyroid extract had no effect on the condition. It was regarded as a case of infantilism associated with, or due to, chronic renal disease dating from the intra-uterine period. Parsons[36] cited a case of a child, six and a half years old, who was not as tall as a normal child of three years. He had polyuria, polydipsia, and oedema of the feet and ankles. Postmortem examination disclosed the typical scarring of chronic interstitial nephritis. At the time of this report chronic interstitial nephritis was supposed to be due to congenital syphilis or parasyphilis. Rachitic deformities were not described, and the Wassermann test was not done, but the infantilism was definite, as was the renal change. Hutinel observed the case of a child thirteen years of age who manifested various changes typical of rickets, associated with albuminuria and decreased renal function, but he did not think that there was any connection between the two conditions. He thought it was a case of dystrophy due to disturbance of the glands of internal secretion. Miller and Parsons thought that there were two types of renal infantilism, one associated with organic renal disease and the other with diabetes insipidus, and that in both types polyuria and polydipsia occurred. Naish described two cases in which there were rachitic deformities associated with albuminuria and dry, wrinkled skin. Both patients died of uraemia, and chronic interstitial nephritis was found at necropsy. Barber described two cases, respectively, in a brother and a sister, in both of which were found signs of infantilism;—namely, stunted growth, polyuria, albuminuria, and dry wrinkled skin. Chronic interstitial nephritis was found at necropsy. Syphilis was definitely excluded. Paterson[38] presented three cases of rachitic deformity in children, associated with albuminuria and casts and decreased renal function. One child died in a state of uraemia.

Fletcher, in 1920, reported his second case. It was that of a boy of fourteen years, with genu valgum, albuminuria, headache, vomiting, and a blood pressure of 240 systolic and 190 diastolic. Paterson, in 1921,

described a child who had typical rachitic deformities, albuminuria, and in whose case the concentration of blood urea was 108 milligrams in each 100 cubic centimeters. He had defective movements at the shoulders, elbows, and knees, with thickening about the elbows, and enlargement of the wrists and ankles. The roentgenograms gave evidence of marked osteoporosis. The shadows of the lower ends of the ulna and radius were faintly stippled and there was evidence of much enlargement, with displacement of the wrist toward the ulna. There was overgrowth of fibrous trabeculae, and failure in the laying down of calcium and bone tissue in the trabeculae, thus explaining the marked tendency to displacement and fractures in these cases. Paterson, in 1922, presented another case in which rachitic deformities were associated with signs of renal insufficiency. In the roentgenograms there was a woolly appearance of the diaphysis, with a straight epiphyseal line. In the lower ends of the femora there was marked irregularity of the epiphyseal line, with definite fracture of the lower end of the diaphysis, extending into the epiphyseal line. There was definite evidence of interstitial nephritis, and Paterson concluded that the same agent which produced the renal fibrosis also brought about the bony changes. He did not think that the cause of this was dietetic. Lathrop presented a case of rachitic deformity associated with renal injury and expressed the belief that retention of phosphate, with resulting low concentration of serum calcium over a long period, might be the cause of delayed ossification of the bones. Brockman described three cases of chronic interstitial nephritis in children associated with changes in bone similar to rickets, and said that the shafts of the bones in renal rickets were straight,—not curved as in true rickets. The deformities, in his opinion, were due to separation and displacement of the epiphyses. The deformity (solution of continuity in the neighborhood of the growth disc) is progressive. He described active absorption of bone by osteoclasts in the region of the growth disc, and of the shaft beneath the periosteum, and its replacement by fibrous tissue. This is increased over the amount found in true rickets. Parsons, in 1927, considered the question in detail and distinguished three types of renal rickets according to the roentgenographic appearance, atrophic rickets, florid rickets, and woolly rickets. He described the cause as being inability of the kidney properly to excrete phosphorus, and said that there was marked lipaemia, retention of nitrogen and phosphate in the blood, and acidosis. He thought that healing might occur when excretion of phosphorus improved or when the period of growth was over. Smith and Walsh described a case of renal rickets, in which a boy of fourteen years had marked genu valgum, high concentration of non-protein nitrogen in the blood, a concentration of serum phosphorus of five and six-tenths milligrams, and of serum calcium of five milligrams in each 100 cubic centimeters. There were subperiosteal fractures of the ulnae and tibiae, and the vertebrae appeared to be fused. The boy died of uraemia at the age of fifteen years. Barber published a series of papers on this condition, and in 1926 stated that he had reviewed the cases of seventeen patients, three of whom were alive. He cited the

outstanding characteristics as being excessive thirst, polyuria, albuminuria, and development of rachitic deformities, notably genu valgum at puberty. He said that the epiphyses rarely unite and that death usually occurs from uraemia in the second decade of life. Miller, Feiling and Holyoak, Watson-Wemyss, Hunt, Karshner, Cockayne, Apert, and Cookson have presented reports of cases varying very little from those described by other authors.

Spence, in an address on chronic nephritis in childhood, made reference to the fact that renal dwarfism or renal rickets often occurs in chronic interstitial nephritis, with actual cessation of growth and development at the epiphyseal line, producing dwarfism. He expressed the belief that the ordinary antirachitic measures are valueless in this disease and said that ultra-violet light brought on convulsions in one of his cases. György described three cases of typical bony deformities and loss of growth associated with nephritis. In these cases, determinations of serum calcium and serum phosphorus were low; determinations of non-protein nitrogen and blood urea were high, and albuminuria, casts, polydipsia and polyuria were present. He stated that he had treated his patients along antirachitic lines, with diet and viosterol (vigantol). He had cured one patient; one patient died of uraemia. Teall, in a roentgenographic study of the disease, distinguished two types: the rachitic type and the woolly type. The rachitic type is identical with ordinary rickets. The woolly type is sufficiently characteristic to be of diagnostic value. He stated that in the woolly type definite osteoporosis, increasing in severity, is evident in the roentgenograms. The trabeculae are thickened and fluffy-looking instead of being of normal outline. The deformities arise in the metaphysis. Ossification is irregular; there is a stippled, woolly appearance, and although the metaphysis is longer than that seen in rickets, it is not so splayed out nor does it have the "champagne-glass" end so typical of ordinary rickets. Teall wrote: "In this metaphysis the bone appears to be eaten away under the periosteum, producing a roentgenographic appearance which always reminds me of a wooden post which has rotted away in the earth. The subperiosteal eaten-away appearance in the metaphysis constitutes the most important feature in the roentgenographic appearance from a diagnostic standpoint." The author also stated that the lesions in the woolly type were asymmetrical, might be much more marked in one bone than in another, and that the appearance of the skull is fluffy, resembling closely that in Paget's disease. Ashcroft presented some cases of renal rickets and said that the roentgenographic appearance is one of rarefaction, metaphyseal abnormality, hazy porosis, enlargement and lack of cortex, associated with trabeculation and other rachitic changes at the epiphyseal line. He stated that the renal lesion is responsible for the albuminuria, and so forth, but that the rest of the picture is due to some other factor, perhaps deficiency of the suprarenal glands. He treated the patients with cod-liver oil, calcium lactate, and thyroid extract, and they improved somewhat. More recently, Duken reported a case in which a boy of six years who presented typical rachitic phenomena at the wrists and knees, and who had a large head and beading

of the ribs, excreted also albumin, blood, pus, and casts in the urine. A culture of the urine was positive for hemolytic streptococci. The concentration of serum calcium was sixteen milligrams and of serum phosphorus, nine milligrams in each 100 cubic centimeters. At necropsy, bilateral hydronephrosis, hydro-ureter with dilatation of the ureters, and many adhesions were found. Cystitis, ureteritis, and pyelonephritis also were present. The author thought that another factor must have been associated with the contracted kidneys and high concentration of blood phosphorus, because these conditions do not always produce bony changes. In this case viosterol (vigantol) made both the bony deformities and the renal condition worse.

Shipley, Park, McCollum, and Simmonds, in commenting on rickets in general, mentioned a child, aged three and a half years, who had marked bony deformity. The deformity differed from that found in ordinary rickets, and was more extensive. The proliferative cartilage was very irregular and the calcification was defective. In the deep metaphysis were large islands of cartilage bordered on one or more sides by dense deposits of calcium. These islands produced a honeycomb appearance in the roentgenogram. The trabeculae were thin and the osteoid borders narrow. The urine had a low, fixed specific gravity in this case and constantly contained albumin. After several attacks of uraemic acidosis, death occurred. At necropsy the kidneys were found to be exceedingly small and defectively developed. The authors advanced the opinion that the rickets was of the variety in which the concentration of calcium in the serum is low, due to inability of the kidney to excrete phosphorus. They expressed the belief that true renal rickets existed, and that it resembled another kind of endogenous rickets. Recently, Schoenthal and Burpee reported two cases of rickets in children which were diagnosed clinically because of bossing of the skull, beading of the ribs, and other deformities, associated with definite evidence of renal insufficiency in the form of albumin and casts in the urine. Unfortunately, roentgenograms were not made, but extensive metabolic studies were carried out. The theory was formulated that two types of renal rickets exist, one due to congenital malformation of the kidney or urinary tract, and the other due to chronic renal insufficiency of the character of chronic interstitial nephritis. These writers expressed the belief that the usual antirachitic measures, such as administration of vitamin D, were of no value. However, they offered the belief that replacement of the depleted stores of calcium and phosphorus, by the giving of an alkaline-ash diet and of calcium acetate, was helpful, but had to be continuous.

COMMENT

In making the diagnosis of so called renal rickets in the case reported, distinction from several other conditions had to be made. These were tumor of the parathyroid glands producing hypercalcaemia and osteomalacia, late rickets, juvenile Paget's disease, and early osteomalacia.

The association of adenomas of the parathyroid glands with bony changes has occasioned the publication of many interesting papers in the last few years. Mandl; Barr, Bulger, and Dixon; Boyd, Milgram, and Stearns; and Wilder have described cases which bear close resemblance to each other. In these cases, bony changes, exemplified by bowing of the long bones, formation of cysts and giant-cell tumors, and a fuzzy, irregular appearance of the skull, were associated with high concentration of serum calcium and low concentration of serum phosphorus. The discovery and removal of tumors of the parathyroid glands promptly reduced the concentration of serum calcium to the point at which tetany appeared in some instances, and relieved the symptoms produced by the abnormal structure of the skeleton. The concentration of serum phosphorus seemed to be unaffected after operation, in these cases. Harbitz, in 1915, reported the association of an adenoma of a parathyroid gland and chronic interstitial nephritis in a patient who had brittle, osteoporotic bones containing many smooth-walled cysts. These bones were soft and porous and could be cut easily. They also fractured from slight trauma. MacCallum found an adenoma of a parathyroid gland in a young man with chronic interstitial nephritis who died of uraemia. Bony changes were not mentioned. Schüler recently reported the death from uraemia of a patient who suffered from non-puerperal osteomalacia from the age of seventeen years to the time of her death at the age of forty-three years. There was extensive involvement of all the bones, and the deformities were extreme. Amyloidosis of the kidneys was found at necropsy, and it was thought that this produced the terminal uraemia. The connection between amyloidosis and osteomalacia was not known by the author. Kerl found osteomalacic changes in bone associated with hyperplasia of the parathyroid glands, and Molineus and Gödel reported association of bony changes of the type of osteomalacia with tumors of the parathyroid glands. Duken expressed the belief that late rickets, osteomalacia, and osteitis fibrosa were all due to endocrine insufficiency, and mentioned the ovary as well as the thyroid gland. Dieterich observed enlargement of the parathyroid glands in a dog with osteomalacia and osteoporosis due to a persisting biliary fistula.

It becomes evident, then, that there is a definite syndrome in which tumors and hyperplasia of the parathyroid glands are associated with changes in bone and high concentration of serum calcium. The connection between abnormalities of the parathyroid glands, changes in bone, and renal insufficiency never has been clearly traced. The writer believes that this syndrome, referable to the parathyroid glands, can be definitely ruled out in the case reported here, because a palpable tumor was not present, the concentration of serum calcium and serum phosphorus was normal, and skeletal changes which are more severe and deforming than any of those ascribed to hyperparathyroidism were present. In the cases of hyperparathyroidism, bowing of the long bones was moderate, and cysts and giant-cell tumors were found, whereas in the case here reported the deformities were extreme and cysts or tumors were not found. Moreover, the marked

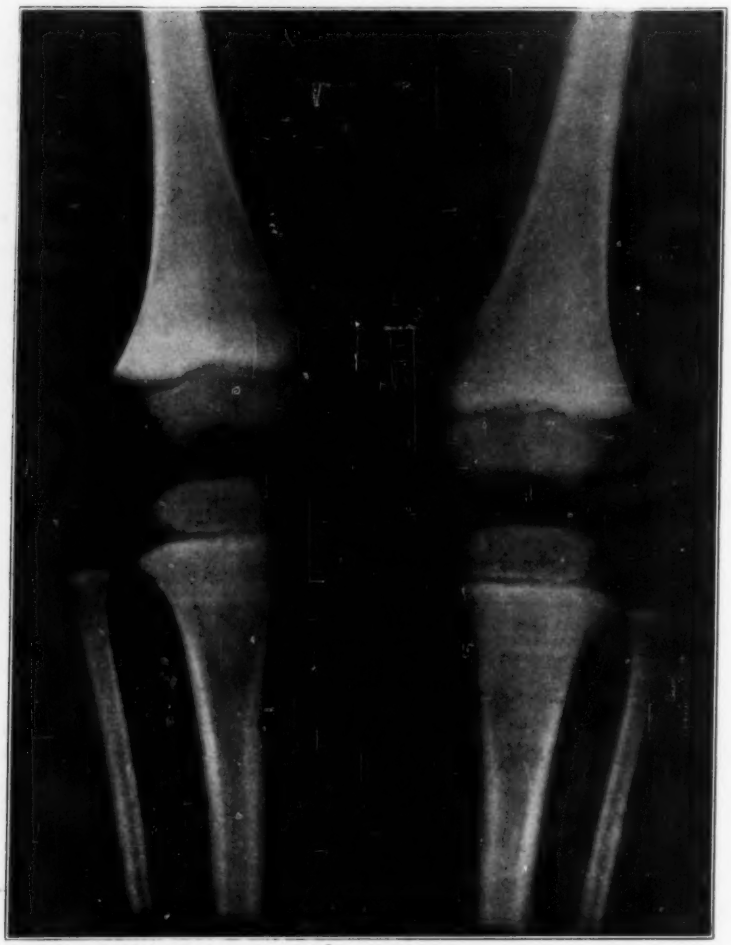

FIG. 5

Widening and flaring of the diaphyses of ordinary rickets in a child aged nine years. There is no calcium deposit at the epiphyseal line and the diaphyses do not show the porosis and softening seen in the previous illustrations.

epiphyseal changes seen in this case were not found in any of the cases of hyperparathyroidism. The only point of close resemblance between the case reported and cases of hyperparathyroidism, seems to be that in this case, and in hyperparathyroidism, the skull resembles that seen in Paget's disease.

Late rickets could be excluded as a diagnosis in this case because the boy had been perfectly well as far as the skeletal system was concerned until the age of fifteen years, and there were no dietetic changes at that time. In addition, the bony changes differed greatly from those of rickets, early or late, and were much more severe. Figure 5 shows the usual flaring and

irregularity of the diaphyses at the epiphyseal lines in a case of ordinary rickets in a child aged nine years.

Juvenile Paget's disease produces thickening of the cortex and the periosteum of the shafts of the long bones, and no epiphyseal changes. In the case under consideration, there was fluffy thickening of the bones of the skull, similar to that seen in Paget's disease, but the bone was not as dense, nor were striations seen, such as are present roentgenographically in Paget's disease. In the one case of juvenile Paget's disease seen at the clinic, there was definite thickening of the shafts of all the long bones, and tremendous thickening of the skull. This occurred in a child two and a half years of age, and there was no evidence of renal insufficiency.

Softening of the bones, with deformity of the long bones similar to that in osteomalacia, was found in the case reported here. In addition, however, the factor of renal insufficiency was present and this has not previously been described as having anything to do with osteomalacia. The case is clearly one with osteomalacic characteristics, but, with the factor of renal insufficiency present, it corresponds more closely to the cases of renal rickets.

Although the roentgenographic appearance of the bones in the case reported does not approximate exactly that found in any of the previously described cases, there is definite evidence of a generalized bony process producing bowing of the long bones, thickening of the periosteum, and deposition of calcium in an irregular manner on the metaphyseal side of the epiphyseal line. This simulated closely the woolly type of deformity described by Teall. The vertebrae were pushed together and thinned out so that the ribs were brought nearer together and the patient lost seven inches in height. The spaces between the teeth were wider and the pelvis was markedly deformed. The roentgenographic appearance in general most closely approximated that pictured by Ashcroft. There had not been fractures of any of the bones. This is contrary to the usual course of events in the various types of osteomalacia. Renal insufficiency was definite, from the following evidence: one kidney had been removed because of hydronephrosis with infection; there was albumin, pus, and blood in the urine from the remaining kidney; a culture of urine contained a gram-negative bacillus; the concentration of blood urea was 218 milligrams in each 100 cubic centimeters; polyuria was present, and death finally occurred from uraemia.

The determinations of serum calcium and of serum phosphorus were not of great value. The reading for serum calcium was within the normal range, and although the concentration of serum phosphorus was slightly increased, the increase was not great enough to be significant. Studies of the calcium balance by determining the excretion of calcium in urine and feces were not carried out, but the history brings forth the fact that for some time previous to his coming to the clinic, the patient and his parents had noticed that there was a heavy, white deposit in the urine on standing. This, possibly, was the excess of calcium being excreted through the kidney and is fairly presumptive evidence of a negative calcium balance.

It is strange that most of the cases of renal rickets have been reported from England; very few have been reported from France, Germany, or the United States. The case reported is the first that has been seen at the clinic. The reported cases of renal rickets vary a great deal in the bony changes described. Renal insufficiency is definite in all of them, but the changes in bone range from the simple knock-knee of the earlier authors to the extensive deformities and epiphyseal changes described by Ashcroft. It may be argued that these cases vary too much to be classified under one heading, but since there are no other criteria for differentiation, and because they have come to be known by the name of renal rickets, the various gradations had better be grouped together rather than separated.

It is difficult to understand why renal insufficiency should cause such extensive changes in bone in isolated instances such as this and not in the many other cases in which it is present. Yet there seems to be no other factor which might account for the bony changes. Tumor of the parathyroid glands, or hyperplasia, might cause such a condition, but this seems to be definitely ruled out. Practically all other cases of osteomalacia reported, besides those due to hyperparathyroidism, are found in women and are believed to be due to food poor in quality and vitamins, unhygienic living conditions, and so forth. This case bears no resemblance to osteomalacia of that type. The possibility might be advanced that the renal insufficiency had stimulated the parathyroid gland to overactivity and had thus produced the skeletal changes. Yet, this seems hardly probable, and it is open to the same criticism as before,—that skeletal changes rarely accompany renal insufficiency, whereas chronic interstitial nephritis or other renal disease which produces insufficiency is frequently found, with absolutely no skeletal changes.

Treatment of this condition involves, chiefly, attempts at correcting the renal condition. In cases of chronic interstitial nephritis this attempt is usually futile. Of course, nothing can be done to overcome the bony deformities before the nephritis is cleared up. Osteotomy in these cases is almost invariably fatal and should never be attempted. The usual antirachitic measures,—such as cod-liver oil, sunlight, good food; and the newer therapeutic aids,—such as viosterol and irradiated foods—are of no value in this condition.

The association of marked osteomalacic deformities with positive evidence of renal insufficiency in the case reported leads to the conclusion that it should be classified under the heading of so called renal rickets.

SUMMARY

A case is described in which marked bony deformity, of the type of osteomalacia, is associated with definite renal insufficiency in a boy of eighteen years.

An attempt is made to show the comparative rarity of the condition by consideration of all the known reported cases.

Differential diagnosis of so called renal rickets, from hyperparathyroidism, late rickets, juvenile Paget's disease, and early osteomalacia is considered.

A question of etiology is still left open although a theory of causation is advanced.

BIBLIOGRAPHY

1. Apert, E.: Les Altérations osseuses dans les Néphrites atrophiques infantiles; Nanisme rénal—pseudo-rachitisme rénal. Presse méd., XXXVI, 577, May 9, 1928.
2. Ashcroft, G. V.: Renal Rickets. J. Bone and Joint Surg., VIII, 279, April 1926.
3. Barr, D. P., Bulger, H. A., and Dixon, H. H.: Hyperparathyroidism. J. Am. Med. Assn., XCII, 951, March 23, 1929.
4. Barber, Hugh: Chronic Interstitial Nephritis in Children: a Brother and a Sister Affected. British Med. J., II, 1204, Nov. 8, 1913.
5. Barber, Hugh: A Case of Interstitial Nephritis with Infantilism. Lancet, I, 142, Jan. 26, 1918.
6. Barber, Hugh: The Bone Deformities of Renal Dwarfism. Lancet, I, 18, Jan. 3, 1920.
7. Barber, Hugh: Renal Dwarfism. Quart. J. Med., XIV, 205, Apr. 1921.
8. Barber, Hugh: Two Cases of Adolescent Knock-knee: I. A Typical Renal Dwarf; II. Late Rickets without Obvious Cause. Guy's Hosp. Rep., LXXII, 62, 1922.
9. Barber, Hugh: Renal Dwarfism: A Study of the Course of the Disease from Seventeen Cases. Guy's Hosp. Rep., LXXVI, 307, 1926.
10. Boyd, J. D., Milgram, J. E., and Stearns, Genevieve: Clinical Hyperparathyroidism. J. Am. Med. Assn., XCIII, 684, Aug. 31, 1929.
11. Brockman, E. P.: Some Observations of the Bone Changes in Renal Rickets. British J. Surg., XIV, 634, Apr. 1927.
12. Cockayne, E. A.: Two Cases of Renal Dwarfism. Proc. Roy. Soc. Med., XXI, 19, Feb. 1928.
13. Cockayne, E. A.: Renal Infantilism. Proc. Roy. Soc. Med., XXI, 1250, Nov. 1928.
14. Cookson, H. A.: Post-mortem Findings in a Case of Renal Dwarfism. British Med. J., II, 196, Aug. 4, 1928.
15. Dieterich, H.: Die porotische Malacie nach Gallenfisteln. Beitr. z. klin. Chir., CXXXIV, 530, 1925.
16. Duken, J.: Beitrag zur Kenntnis der malacischen Erkrankungen des kindlichen Skelettsystems. I. Mitteilung. Spätrachitis und Osteodystrophis fibrosa. Ztschr. f. Kinderh., XLVI, 114, 1928.
17. Duken, J.: Beitrag zur Kenntnis der malacischen Erkrankungen des kindlichen Skelettsystems. II. Mitteilung. Spätrachitis, Tetanie und chronische Schrumpfniere (Renale Rachitis). Ztschr. f. Kinderh., XLVI, 137, 1928.
18. Feiling, A. and Holyoak, W. L.: Case of Renal Dwarfism with Optic Atrophy. Proc. Roy. Soc. Med., XV, 1, Oct. 14, 1921.
19. Fletcher, H. M.: Case of Infantilism with Polyuria and Chronic Renal Disease. Proc. Roy. Soc. Med., IV, 95, Mar. 24, 1911.
20. Fletcher, H. M.: Case of Renal Infantilism. Proc. Roy. Soc. Med., XIII, 118, Apr. 23, 1920.
21. Gödel, A.: Epithelkörperchentumoren bei tumorbildender Ostitis fibrosa. Wien. klin. Wchnschr., XXXVIII, 246, Feb. 1925.
22. György, P.: Über renale Rachitis und renalen Zwergwuchs. Jahrb. f. Kinderh., CXX, 266, 1928.
23. Harbitz, Francis: On Tumors of the Parathyroid Glands. J. Med. Res., XXXII, 361, July 1915.

24. Hunt, F. C.: Renal Infantilism: Report of a Case and a Review of the Literature. Am. J. Dis. Child., XXXIV, 234, Aug. 1927.
25. Hutinel, V.: Late Rickets with Muscular Weakness, Obesity and Retardation of the Generative Functions. Abstract, British J. Child. Dis., IX, 513, Oct. 1912.
26. Karshner, R. G.: Rickets Occurring Late in Chronic Interstitial Nephritis: Report of a Case. Am. J. Roentgenol., XVIII, 442, Nov. 1927.
27. Kerl, F.: Zur Frage der Epithelkörperchenhyperplasien bei Osteomalazie und Osteoporose. Deutsche. med. Wchnschr., LI, 1271, July 1925.
28. Lathrop, F. W.: Renal Dwarfism: Report of a Case. Arch. Int. Med., XXXVIII, 612, Nov. 1926.
29. Lucas, R. C.: On a Form of Late Rickets Associated with Albuminuria, Rickets of Adolescents. Lancet, I, 993, June 9, 1883.
30. MacCallum, W. G.: Tumor of the Parathyroid Gland. Bull. Johns Hopkins Hosp., XVI, 87, Mar. 1905.
31. Mandl, Felix: Therapeutischer Versuch bei einem Falle von Ostitis fibrosa generalisata mittels Exstirpation eines Epithelkörperchentumors. Zentralbl. f. Chir., LIII, 260, Jan. 1926.
32. Miller, Reginald: Chronic Interstitial Nephritis with Infantilism. Proc. Roy. Soc. Med., V, 38, Nov. 24, 1912.
33. Miller, Reginald and Parsons, Leonard: Renal Infantilism. British J. Child. Dis., IX, 289, July 1912.
34. Molineus: Über die multiplen braunen Tumoren bei Osteomalacia. Arch. f. klin. Chir., CI, 333, May 1913.
35. Naish, A. E.: Infantilism with Chronic Interstitial Nephritis. British J. Child. Dis., IX, 337, Aug. 1912.
36. Parsons, Leonard: Infantilism Associated with Chronic Interstitial Nephritis. British Med. J., II, 481, Sept. 2, 1911.
37. Parsons, Leonard: The Bone Changes in Renal and Coeliac Infantilism, and Their Relationship to Rickets; Renal Rickets. Arch. Dis. Child., II, 1, Feb. 1927.
38. Paterson, D. H.: Three Cases of Renal Dwarfism Associated with Curious Bony Changes. Proc. Roy. Soc. Med., XIII, 107, June 1920.
39. Paterson, Donald: A Case of Renal Dwarfism with Bony Changes. British J. Child. Dis., XVIII, 186, Oct.-Dec., 1921.
40. Paterson, Donald: A Case of Renal Dwarfism. Lancet, I, 944, May 13, 1922.
41. Schoenthal, Ludwig and Burpee, Claude: Renal Rickets. Am. J. Dis. Child., XXXIX, 517, Mar. 1930.
42. Schüler, W.: Über einen Fall schwerster nicht puerperaler Osteomalazie. Frankfurter Ztschr. f. Path., XXXVII, 270, 1929.
43. Shipley, P. G., Park, E. A., McCollum, E. V. and Simmonds, Nina: Is There More than One Kind of Rickets? Am. J. Dis. Child., XXIII, 91, Feb. 1922.
44. Smith, D. C. W. and Walsh, M. D.: Rickets and Subsequent Dwarfism Associated with Renal Disease: Report of a Case. Southern Med. J., XX, 437, June 1927.
45. Spence, J. C.: Chronic Nephritis in Childhood. British Med. J., II, 1124, Dec. 22, 1928.
46. Teall, C. G.: A Radiological Study of the Bone Changes in Renal Infantilism. British J. Radiol., I, 49, Jan. 1928.
47. Watson-Wemyss, H. L.: Chronic Interstitial Nephritis in Childhood: Renal Infantilism (?): A Clinical Record with Postmortem Report. Edinburgh Med. J., XXIX, 300, Dec. 1922.
48. Wilder, R. M.: Hyperparathyroidism: Tumor of the Parathyroid Glands Associated with Osteitis Fibrosa. Endocrinology. XIII, 231, May-June 1929.

A CRITICAL ANALYSIS OF THE ANATOMY AND THE PATHOLOGIC CHANGES OF THE SACRO-ILIAC JOINTS*

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Meckel[1] in 1816 was the first to describe the sacro-iliac joint. Under the heading of the sacro-iliac symphysis in Volume II of his Textbook of Human Anatomy, he made the interesting observation that the articulating surfaces of this joint are covered with cartilage, and noted that these are smooth in youth but become rougher as age advances. Barkow[2] in 1841 noted that the joint cavity in nearly all individuals was open, and mentioned that a marked tendency to ankylosis exists. Von Luschka[3] in 1854 was the first to consider the sacro-iliac articulations as constituting true diarthrodial joints. It is of interest to note that many anatomists have not accepted his findings. Gray[4, 5], Braus[6], Heisler[7], and Berry[8] class the sacro-iliac articulations as amphiarthrodial joints. Testut[9] described the articulation as a diarthro-amphiarthrodial joint. Rauber and Kopsch[10] classify the articulation as belonging somewhere between a synarthrose and diarthrose. On the other hand we find Morris[11], Cunningham[12], Rouviere[13], and Fick[14] maintaining that the sacro-iliac articulations are true diarthrodial joints.

The anatomic picture of these articulations, unlike that of any other joint in the body, is not as yet firmly established. The confusion that still prevails may be explained by the early onset of pathologic changes in the joints, so that one must be careful not to deal with pathologic specimens when describing the normal anatomy. The sacro-iliac articulations are diarthrodial up to early adult life, but after this motion almost always disappears, and they become amphiarthrodial or completely ankylosed.

In this paper an attempt is made to state the anatomic nature of the sacro-iliac joint as found by the author, and to describe the pathologic changes that take place in the two sexes at the different age periods. The study is based on 257 post-mortem examinations in which both sacro-iliac joints were removed.

In 114 cases the joints were macerated and studied for such changes as osteophytes and bony ankylosis. In 143 cases the joints were studied in the fresh state for evidences of subluxations, abnormal mobility, and for changes in the ligaments, joint cavities, and cartilages.

The material was divided into three groups according to age and sex:

Group I: Up to 29 years — 43 cases (32 fresh, 11 macerated).
Group II: 30 to 59 years — 111 cases (59 fresh, 52 macerated).
Group III: 60 and above — 103 cases (52 fresh, 51 macerated).

*This work was done at the laboratory of Geheimrat Prof. Schmorl of the Pathologic Institute at the "Stadt Krankenhaus Dresden-Friedrickstadt", from October 1928 to April 1929, and since then at the Hospital for Joint Diseases, New York City.

Sections for microscopic study were taken from the fresh specimens of ten cases of the first group, and of nearly half of the second and third groups. The microscopic sections were made from material embedded in gelatin, paraffin, or celloidin. They were stained with hematoxylin and eosin, some with Sudan III, and several with Weigert's elastic tissue stain. The gelatin-stained sections were mounted in glycerin-gelatin. The others were mounted in balsam. The bone was decalcified in five per cent. nitric acid, or in Müller's solution, plus five per cent. glacial acetic acid.

GROUP I. 43 Cases

Normal Anatomy

The normal anatomy of the sacro-iliac joints can only be completely understood by examining the joints of the first group of cases, namely from individuals less than thirty years of age. In thirty-two cases both sacro-iliac joints were examined in the gross while still in situ and subsequently outside of the body. There were fifteen males and seventeen females, (one patient was one year old, and one was fifteen; the rest were over sixteen). There were no gross evidences of any changes in these cases, with the exception that in two the joints were slightly subluxated. This was due to a severe trauma, and they will be discussed later. In eleven specimens (six males and five females), the joints were completely macerated. There were no evidences of pathologic changes.

On separation of the joint surfaces a striking difference is noted in shape, contour, color, and consistency of the opposing layers of cartilage. In form the articulating surfaces closely resemble the external auricle. The surfaces are not regular; the articulating surface of the sacrum being concave, while that of the ilium is convex. The lining cartilage is hyaline. That over the sacrum is smooth, glistening, and grayish-white in color. Its thickness varies from one to four millimeters. The cartilage lining the ilium is slightly bluish, dull, and striated. This surface is grooved by transverse radiating lines, giving it a striped appearance. The articulating cartilage is thin, in places membrane-like, and varies in thickness from one-half to two millimeters. The joint surface area varies from six and four-tenths by two and two-tenths to seven and two-tenths by three centimeters. Brooke[15] found the average surface area at birth to be one and five-tenths square centimeters, at puberty seven square centimeters, and in adults seventeen and one-half square centimeters. Albee[16] found the average surface area in his series of fifty sacro-iliac joints to be seven centimeters in length and three centimeters in width; the largest was eight centimeters by three centimeters, and the smallest six centimeters by two and five-tenths centimeters (See Figure 1).

Joint Cavity

The joint cavity is narrow, being described by many investigators as a slit. A cross section of the joint clearly shows the existence of a space, but

often this is so narrow that the articulating surfaces appear to touch each other. Near the middle of the joint, the space is as a rule widest.

Synovial Membrane

A synovial membrane was always noted. It is a smooth, moist layer, and lines the inner margin of the joint capsule. Von Luschka[17] demonstrated the presence of a synovial membrane at the margins of the articulating cartilages; anteriorly it lined the joint capsule, while posteriorly it was lost with the fibers of the interosseous ligament.

Synovial Fluid

When the sacro-iliac joints were opened at autopsy, the articular cartilages were moist; there was no free fluid in the joint space, but the cartilages were distinctly moistened. In no case of this series was a purulent exudate discovered. A slight amount of free fluid in both sacro-iliac joints was evident in two pregnant women. Meckel[18] described the joint fluid as thicker than the usual synovial fluid. Köllicker[19] in 1850 was the first observer to describe a synovial-like fluid in the joint cavity.

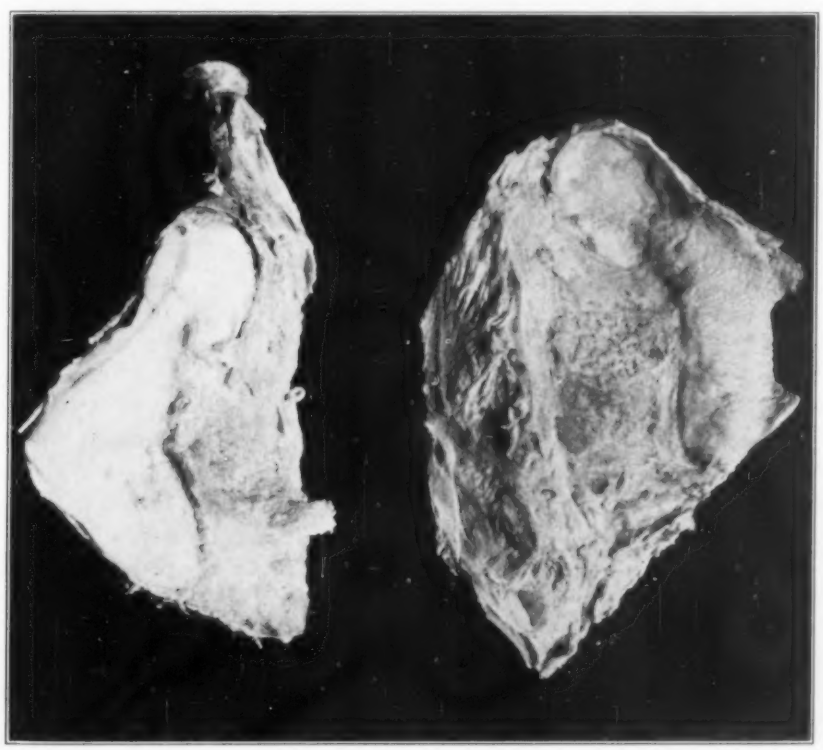

FIG. 1

Normal sacro-iliac joint—male—age 21.
At the left, sacral surface with smooth articular cartilage. At right, iliac surface; cartilage is striated. Note auricular shape of articular surfaces.

Ligaments

The sacro-iliac joints have strong, resistant, and well developed ligaments. The articular capsule is strong and covers the joint over the anterior and partly over the proximal and distal aspects of the joint. Posteriorly, the fibers of the capsule are interwoven with the interosseous and posterior sacro-iliac ligaments. Anteriorly, the capsule blends with the fibers of the anterior sacro-iliac ligament, which passes from the outer anterior aspect of the sacrum to the anterior medial border of the ilium. The anterior sacro-iliac ligament is a thin, rather weak structure. Upon slight pubic separation it is stretched and very often tears.

To determine the amount of pubic separation necessary to completely tear this ligament, the symphysis pubis was cut through in a girl of twenty, who came to autopsy following a septic abortion in the fourth month of pregnancy. By manual separation of the cut ends it was found that upon a separation of five and three-tenths centimeters many anterior fibers ruptured. When the pubic separation reached six and two-tenths centimeters the joint capsule tore from its insertion, throwing the joint surfaces wide apart. In a married woman of forty-four, who came to autopsy following erysipelas, a pubic separation of four and five-tenths centimeters tore many anterior fibers, and when the pubic separation reached five and seven-tenths centimeters, the joint surfaces were opened. Sansten[20] reports that the anterior sacro-iliac ligaments ruptured in forty-four per cent. of cadavera when the pubic separation was below six centimeters.

The interosseous ligament lies directly posterior to the articular cartilage. It consists of numerous short and very resistant bands which are firmly attached to the opposing bony surfaces, and which pass from one bone to the other in different directions. The meshes between the fibers are filled with a soft areolar connective tissue, fat elastic tissue, and contain numerous blood and lymph vessels. Meckel stated that the interosseous fibers are never torn when the bones are forcibly separated; the fibers detach themselves from one bone and remain fixed to the other. The experience of the writer fully confirms this.

In back of the interosseous ligament, and interwoven with it, are the posterior sacro-iliac ligaments (longus and brevis). These ligaments are very strong. With the interosseous ligament, the posterior ligaments offer a strong safeguard against separation of the sacro-iliac joints.

In back of and close to the posterior sacro-iliac ligaments are the fibers of the sacrotuberous and sacrospinous ligaments. The direction and course of the fibers of the former are from the posterior anterior spine of the ilium and from the third, fourth, and fifth segments of the sacrum, passing downward to the tuberosity of the ischium. The fibers of the sacrospinous ligament extend from the last two segments of the sacrum and first segment of the coccyx to the tip of the spine of the ischium. Slocumb and Terry[21] in a paper on the influence of the sacrotuberous and sacrospinous ligaments in limiting movements of the sacro-iliac joints, found that with the sacrotuberous and sacrospinous ligaments in place, no backward movement of

the lower part of the sacrum occurred; but when these were cut, a slight backward movement of the sacrum was possible in every case.

Relaxation of Ligaments

The relaxation of the ligaments surrounding the sacro-iliac joints was found in four instances,—all females. Two of these, one a young woman of twenty-three and the other of twenty-six years, had normal deliveries just before death. In the third case, a woman of twenty-seven years had delivered an eight-months' premature foetus shortly before death, while the fourth, a twenty-year-old girl, died of septic abortion in the fourth month of pregnancy. In these cases the capsule was found loose, thinned out, and relaxed. A separation of the joint surfaces of over six-tenths of a centimeter or one-quarter of an inch, was easily obtained by manual traction. Di Gaspero[22] reports that the anatomist, F. V. Müller, obtained a separation of four centimeters in a girl dying late in pregnancy.

Relation of the Lumbosacral Cord to the Sacro-iliac Joint

The lumbosacral cord lies directly over the lower third of the sacro-iliac joint. In this region nothing except the joint capsule intervenes between the nerve trunk and the joint space. It is of considerable importance to bear this relationship in mind because the nerve may be affected when the joint is subject to inflammatory processes, or traumas. Osteophytes may also extend and irritate the sciatic nerve. The closeness of the nerve to the joint strongly impresses one with the possibility of a direct causal relationship between joint affections and the nerve. Goldthwait and Osgood[23] twenty-five years ago expressed the belief that sciatic pains may be due to pressure of hypertrophic tissue upon the lumbosacral cord as it passes over the joint.

Mobility

Motion in the sacro-iliac joints is only slight at best. It consists of a gliding up and down, and slight anterior-posterior movement. It varies with the age and sex of the individual. During gestation it is always increased. As age advances motion is diminished, and later it very frequently disappears completely because of fibrous and bony ankylosis. In men motion begins to disappear at about the fourth decade, while in women rarely before the fifth decade, but more commonly at the end of the fifth.

To determine the range of motion in the sacro-iliac joints, the posterior half of the pelvis (including the lower lumbar vertebrae, the sacrum, coccyx, both sacro-iliac joints, and part of the posterior aspects of the iliac bones) was removed. The anterior aspects of both joints, up to the anterior sacro-iliac ligaments, were exposed. Then the outer ends of the specimens were held firmly in place, and manual pressure was applied to the lower end of the sacrum. On the other hand, in a number of cases the sacrum was fixed, and pressure was applied to the cut ends of the iliac bones. A gliding up and down, with a slight anterior-posterior movement, was obtained in every specimen of Group I. The degree of mobility was carefully deter-

mined by measuring the amount of excursion of two fixed points, one over the ilium and the other over the sacrum, near the articulation, and these were placed on a line perpendicular to the articular surfaces. The average motion obtained in Group I was four degrees; the maximum motion, eight degrees; and the minimum, two degrees. The maximum mobility of the joints was obtained in a woman who shortly before her death had a full-term delivery. It is important to bear in mind that the cases were all examined within twenty-four to forty-eight hours after death, and that the maximum age of the group was twenty-nine years.

A perusal of the literature on this subject brings out the following data: G. H. Meyer[24], in 1878, found that the sacrum between the ilia possesses a definite mobility. Gustave Klein[25] (postmortem specimens, ninety per cent. of which were females; the oldest case was in the fifth decade) in 1891, found that under a pressure of twenty-five kilograms, the average motion obtained was four degrees; the maximum motion, twelve degrees; minimum, zero degrees; the latter were ankylosed. Goldthwait and Osgood[23] (1905) examined twenty pelves at autopsies; in all but one, motion was clearly demonstrated. Mobility was determined by driving one nail into the ilium near the articulation, and the other into the sacrum, parallel to the first. By raising the leg to about fifty degrees with the knee straight, the ends of the nail separated on an average of three millimeters. Albee (1909) examined fifty specimens, and reported that distinct motion was elicited and measured in every case except one. Brooke obtained a maximum degree of motion in a woman of twenty-five. He states that increased mobility is recognized in a pregnant woman, as early as the fourth month of pregnancy.

Normal Histology

The articular surfaces of the joint are covered with hyaline articular cartilage which, as mentioned under the gross description, is much thicker over the sacrum than over the ilium. The free surfaces of the cartilage are as a rule smooth, though in some a slight irregular unevenness exists which is nearly always more pronounced over the ilium than over the sacrum. The cartilage cells near the free surface of the sacral cartilage are small, spindle-shaped, and compactly arranged with their long axes parallel to the free surface. The intercellular matrix of the free margin of the sacral cartilage appears fibrillar; posteriorly, near the interosseous membrane the fibrillar layer is thick; but as one proceeds anteriorly it thins out to a single cell layer covering the joint surface of the articular cartilage. As one goes from the free surface down to the cartilage-bone junction the cells become round, oval, or bean-shaped; they appear large and less compact; and are seen singularly or in pairs, as typical hyaline articular cartilage cells. The intercellular chondromucinous matrix in the deeper layer of the sacral cartilage is of a varying density but homogeneous throughout. Over the free surface of the ilium the cells are spindle-shaped and the intercellular matrix fibrillar. As one goes down toward the bone the cells not only

become larger and round as over the sacrum, but are seen grouped in clumps of ten to as many as thirty cells each and are arranged in column formations, which appear to run at right angles to the free surface. The intercellular matrix is in places homogeneous, in others fibrillar; often radiating streaks are seen running toward the joint surface. (See Figure 2.)

With the exception of two cases which were pathologic there were no changes in the articular cartilages of the specimens in this group. The microscopic changes in these specimens were of the same order as those seen in Group II, but very much less pronounced.

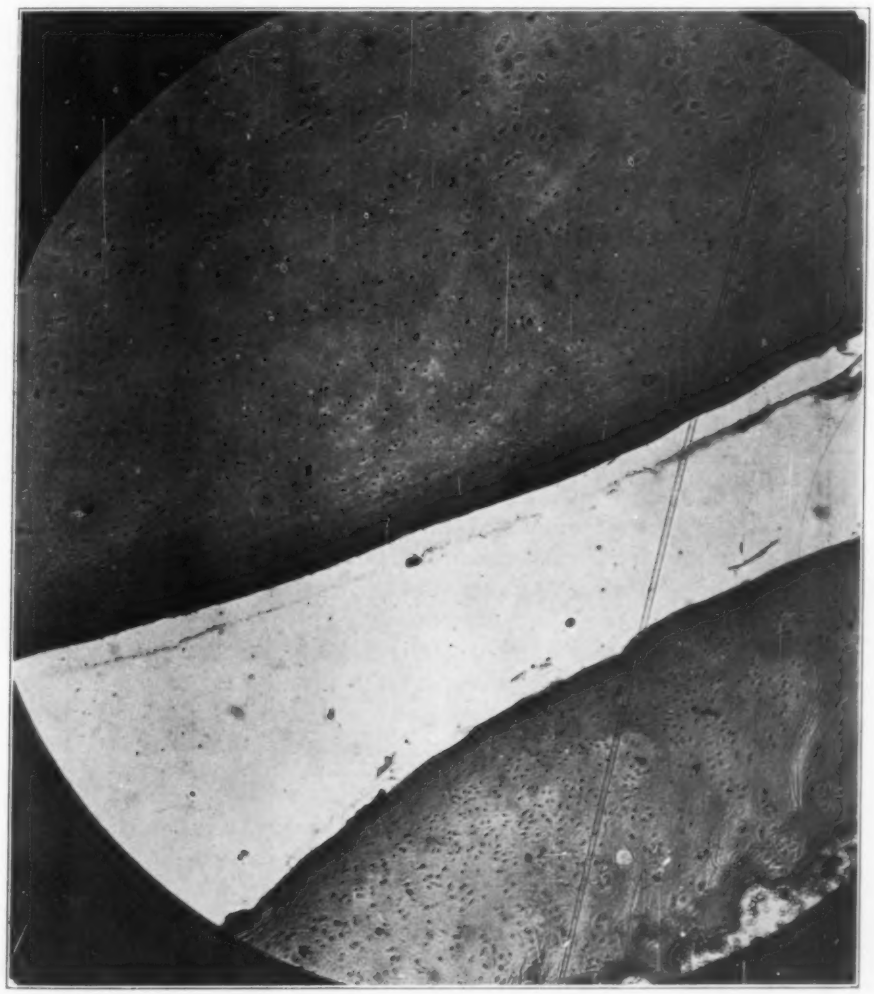

FIG. 2

Photomicrograph, normal—male—age 21.
Upper layer, sacral cartilage; lower, iliac cartilage. Note differences in cell arrangement, intercellular matrix, and thickness of articular cartilage. Celloidin section, stained with hemotoxylin eosin. × 50.

Subluxation

The occurrence of displacements or subluxations of the sacro-iliac joints is rare. In only two cases were there any evidences of this condition. Two young men coming to autopsy following traumatic injuries sustained in accidents showed this. One of them had a fracture of the skull and numerous contusions over the body. On examination of the sacro-iliac joints there was slight subluxation. The other case sustained a fracture of the pelvis. The joint displacement was one centimeter.

Macerated Specimens

When the soft tissues,—such as, muscle, fascia, ligaments, and cartilage—surrounding the sacro-iliac joints were removed by complete maceration, the true bony structure, outline, and architecture of the joints could be observed. There are no protecting or connecting tissues to mask the shape and form of the joints. Now, irregularities of the bone,—as cortical thickenings or osteophytic formations about the margins of the joints—are easily recognized. In this group, eleven cases were completely macerated*; of these six were males and five females. They varied in age from twelve to twenty-nine years. In none of them were pathologic changes present.

SUMMARY OF GROUP I

1. The sacro-iliac articulations are true diarthrodial joints. The joint surfaces are covered with hyaline articular cartilage; there is a joint space, synovial membrane, synovial fluid, and slight motion.

2. Mobility is only slight at best. It was present in all the sacro-iliac joints of this group, and was uniformly increased during pregnancy.

3. Relaxation of the ligamentous structures surrounding the joints was a common feature of parturition.

4. Subluxation or slight displacement of the sacro-iliac joints was seen in two cases, and both followed severe sudden trauma.

5. Early degenerative changes in the articular cartilage of the sacro-iliac joints were noted microscopically in two cases. In none of the macerated cases were any evidences of osteophyte formation or osteo-arthritis noted.

*The method used in macerating the joints is the one routinely employed in Schmorl's laboratory. As much of the soft tissue as possible is removed, and the specimen inserted in a seven per cent. solution of anti-formin, and heated for several hours at sixty to eighty degrees, centigrade. It is then placed in a water bath and the remaining soft tissues are carefully removed. The specimen is thoroughly washed in running water from twelve to twenty-four hours. On the next day it is placed in an aqueous solution of hydrogen peroxid, at a temperature of forty-five degrees, centigrade, and left there for two days. Following this it is exposed to the air, usually in a warm place, and allowed to dry. Finally, the bone is defatted with benzin. The specimens are placed in a closed container, in which heated or vaporized benzin percolates through them. This continues for several hours, and should be repeated if, after drying, the bones are still fatty. The final result is a clear, dry, and white specimen. The whole process is very simple and takes only from six to eight days.

GROUP II. 111 Cases—Ages Thirty to Fifty-nine

In this group the appearance of the joint may vary anywhere from the normal, as seen in the preceding group, to one in which the articular cartilage is eroded and joint surfaces ankylosed. Among the first changes noticed is that the articular cartilage over the sacrum has lost its smooth, glistening, and cream-white color and has assumed a yellowish hue, often appearing as if a yellow powder has been sprinkled over it. The iliac cartilage on the other hand becomes irregular, granular, often very roughened, and coated here and there with yellow plaques. When the joint of a man in the fourth decade is examined, the changes are likely to be more pronounced. The sacral cartilage at this age may become uneven, irregular, and granular. It has a dull light yellow appearance. Over the ilium, the articular cartilage is usually very irregular and coarsely granular; around its margins are erosions and bony irregularities, or osteophytes. In some cases, too, fibrotic changes appear in this cartilage and loose strands may be seen free in the joint space. Mobility of the joint is as a rule markedly diminished, and may be imperceptible. In a male at the fifth decade, one very frequently finds the cartilages irregular. There are erosions, tears, and fibrotic changes, with connective-tissue strands connecting the joint surfaces. Mobility is gone, and fibrous and bony ankylosis are common. In women the changes are not as marked; grossly, the changes are slight up to the fifth decade. Motion, although slightly diminished is obtainable. In the female during the fifth decade the joints appear differently. Irregularities, coarse granulations, and fibrotic changes, as observed in the male joints, become apparent, and motion, although still present in most of the cases, has diminished, and in a few joints is imperceptible.

In both sexes, degenerative changes become more evident and more pronounced with the advance of age. In men, the process starts earlier, and proceeds faster and with greater intensity. Thus, macroscopically, pathologic degenerative changes were present in ninety-one per cent. of the male joints. In female joints, the changes were of a lesser degree, and were present in seventy-seven per cent. of the cases examined. Microscopically, all the cases showed changes of varying degree in the joints.

The following cases illustrate the gross and microscopic changes during each decade.

Case 1—Female, age thirty-three.

Anatomic diagnosis: Carcinoma of uterus with metastases.

Motion of the sacro-iliac joints is present.

Macroscopic Examination: The articular cartilages present slight changes. Over the sacrum the cartilage is smooth, but slightly uneven, and has a slight yellowish hue. Over the ilium the cartilage appears granular and in places rough and irregular.

Microscopic Examination: Several sections were examined. Over the sacrum the free surface of the cartilage is slightly irregular, in places loosened, and here and there small linear tears may be seen extending through the articular cartilage. Over the ilium the free surface is irregular and in several places it is torn and loosened. At one end of the section there is a small degenerated area near the free surface of the cartilage. The microscopic picture is one of early beginning degeneration of the cartilage.

CASE 2—Female, age forty.

Clinically the patient had polyarthritis with deformity of nearly all the joints of the body.

Anatomic diagnosis: Immediate cause of death was broncho-pneumonia.

No motion of the sacro-iliac joints was present.

FIG. 3

Gross section of part of iliac articular surface—female—age 40—Case 2.

Note irregular eroded areas, with surrounding dark vascular tissue.

Macroscopic Examination: Both knees, hips, and sacro-iliac joints were examined. In all of them, a thick, yellowish, adhesive fibropurulent exudate, with degenerative changes of the articular cartilages, was found. The articular cartilages over the sacro-iliac joints presented marked changes. Over both articular surfaces there were several small eroded areas, surrounded by very vascular tissue. The articular cartilage over the sacrum was covered with a thick yellow exudate. Over the ilium the cartilage appeared in places fibrovascular. There were several raised degenerative areas, and in places the cartilage was completely replaced by vascular connective tissue. (See Figures 3 and 4.)

Microscopic Examination: Sections show extensive irregularities of the free surfaces. Small irregular eosin-stained, degenerated areas completely replaced by vascular connective tissue are seen, and each is more than a low-power field in diameter. Plasma cells and lymphocytes are seen infiltrated about the blood vessels. There is a marked proliferation and engorgement of the vessels. In places there is evidence of resorption of the old bone and some new bone formation is observed around the joint space.

CASE 3—Male, age forty-three.

Anatomic diagnosis: Lues and cirrhosis of the liver.

Motion of the sacro-iliac joints is imperceptible.

Macroscopic Examination: The articular cartilage over the sacum is irregular and is of a yellowish-blue color. At its periphery several small eroded areas are seen Over the ilium the cartilage in many places is very rough, irregular, and covered with irregular yellow plaques. About the periphery there are several small eroded areas.

Microscopic Examination: Serial sections were examined. Over the sacrum small raised degenerated areas without normal cellular outlines are present. The deeper layers of the cartilage show nothing unusual. Over the ilium the articular cartilage shows more pronounced changes. The free surfaces are covered with connective-tissue strands which extend into the joint space. There are several linear tears of the cartilage down to the bone junction. The intercellular matrix is for the most part fibrillar.

CASE 4—Female, age forty-six.

Anatomic diagnosis: Mitral stenosis.

Slight motion of the sacro-iliac joints is present.

Macroscopic Examination: The sacral articular cartilage is yellow, dull, and in places, particularly at its periphery, irregular and roughened. Over the ilium the car-

FIG. 4

Photomicrograph—female—age 40—Case 2.
Note vascular connective-tissue replacement of cartilage and marked engorgements of blood vessels. Paraffin section; stained with hemotoxylin eosin. × 50.

tilage appears coarsely granular, dull, and is of a yellowish-blue hue. There is a small irregular raised vascular area, near the anterior margin of the cartilage.

Microscopic Examination: Over the sacrum, in one place there is a small irregular elevated area, with one or two small tears running through it. Over the ilium an area of articular cartilage corresponding to a low-power field is completely replaced by vascular connective tissue, extending right down to the bone. This vascular connective tissue is quite hemorrhagic, and numerous small vessels from the underlying bone extend into it.

CASE 5—Male, age forty-seven.

Motion of the sacro-iliac joint is not obtainable.

Macroscopic Examination: The joint surfaces are very irregular, coarse, and uneven. They appear swollen and oedematous. Over the sacrum the cartilage is rough and coarsely granular. Over the ilium the articular cartilage is very irregular, coarsely granular, and uneven. In places it is soft and cystic.

Microscopic Examination: Several sections were examined. The free surfaces are uneven and irregular. Over the sacrum the cells appear larger than normal; are round and, in places, clumped. The lacunae appear distended and ballooned out with the cellular outline indistinct. In some the lacunae have coalesced into large, clear, whitish areas, giving one the impression of small cysts. As the cartilage is followed downward to the bone, the cells begin to take on a normal appearance. Over the ilium the cartilage appears markedly changed. The cells are pale, small, and in places ill-defined and clumped in groups. The matrix is fibrillar throughout. As one examines the cartilage near the bone junction the irregular clumping of the cells and the irregular fibrillation of the matrix persists. In some places the cell lacunae as seen over the sacrum are distended and massed with other lacunae, presenting numerous small clear areas. The

whole picture is one of a simple diffuse degeneration of the articular cartilage. (See Figure 5.)

CASE 6—Male, age fifty-three.—Very well developed and obese.

Anatomic diagnosis: Lobar pneumonia.

Motion of the sacro-iliac joints is not present.

Macroscopic Examination: Both articular surfaces were bound together with fibrous bands. The sacral surface was very irregular and rough, in places fibrous strands were seen extending from the free surface. Over the ilium the cartilage was in places entirely replaced by fibrous tissue. Around the periphery, the cartilage was eroded and slight bony irregularities and osteophytes were noted.

Microscopic Examination: Section shows marked connective-tissue replacement and proliferation over the free surfaces of the articular cartilage. Fibrous strands passing from surface to surface were seen in all of the sections. In places connective-tissue replacement of the entire cartilage was found.

Over the ilium at the cartilage-bone junction are numerous vessels invading the cartilage from the bone.

This is a typical case of fibrous ankylosis of the joint. (See Figure 6.)

CASE 7—Male, age fifty-seven.

Anatomic diagnosis: Pneumonia following influenza.

Motion of the sacro-iliac joints is not present.

Macroscopic Examination: The joint space was filled with a yellowish, purulent exudate. The articular surfaces were irregular, in places eroded, and throughout covered with the thick purulent exudate.

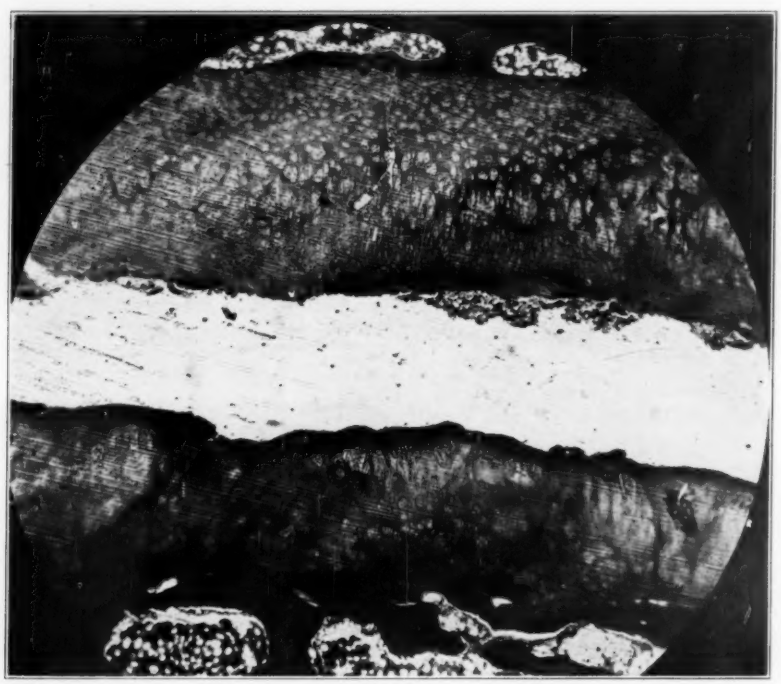

FIG. 5

Photomicrograph—male—age 47—Case 5.

Lacunae of upper layer, sacral cartilage, and lower iliac cartilage are distended; cellular outline is indistinct; intercellular matrix is fibrillary. Celloidin section, stained with hemotoxylin eosin. × 24.

Microscopic Examination: The sections show the articular cartilage irregularly covered with an eosin-stained exudate. Numerous pus cells are found. The upper layer of the sacral cartilage is rough and in places replaced by connective tissue. Over the ilium the cartilage is entirely covered with this eosin-stained, purulent exudate. Fibrous replacement of the cartilage is present. At the cartilage-bone junction are numerous, injected, and engorged blood vessels.

FIG. 6

Photomicrograph—male—age 53—Case 6. Fibrous ankylosis. Upper layer, sacral cartilage, lower iliac cartilage. Note fibrous strands connecting surfaces. Gelatin section, stained with hemotoxylin eosin. × 100.

Comment

The cases cited show the typical uniform involvement of the articular cartilages found in this group. The changes are irregularities in the articular surfaces; small and large tears of the articular cartilages, some of which extend down to the bone; slight fibrous replacement of the cartilage, often with fibrous bands free in the joint; and vascular proliferation with small hemorrhagic areas at the cartilage-bone junction. These changes varied with the age and with the sex of the patient, but as a rule the degenerative changes with fibrous replacement and fibrous ankylosis were more marked,

TABLE I

MACERATED SPECIMENS—GROUPS I AND II

OSTEO-ARTHRITIC CHANGES AND BONY ANKYLOSIS OF THE SACRO-ILIAC JOINTS

AGE	TOTAL NO. CASES	OSTEOPHYTES Around Joint Margins				BONY ANKYLOSIS			
		Beginning	*Moderate*	*Advanced*	*Per cent.*	*Beginning*	*Moderate*	*Advanced*	*Per cent.*
				MALES					
Up to 29	6	0	0	0	0	0	0	0	0
30–39	5	3	0	0	60	0	0	0	0
40–49	7	5	1	0	86	4	0	0	57
50–59	23	6	12	5	100	9	3	2	60
				FEMALES					
Up to 29	5	0	0	0	0	0	0	0	0
30–39	6	1	0	0	16	0	0	0	0
40–49	4	2	0	0	50	0	0	0	0
50–59	7	4	2	0	86	1	0	0	14

and were seen earlier, in the male. In Case 1 early degenerative changes were noted. In Cases 3 and 5 more general and more advanced degenerated areas were observed. In Case 2 gross evidence of a fibropurulent exudate with several fibrohemorrhagic degenerative areas of the cartilage were noted. Histologically, areas of vascular connective-tissue replacement of the articular cartilage, plasma cells, and lymphocytic infiltrations around the blood vessels were seen. In Case 4 small areas of vascular connective tissue, replacement of the articular cartilage, were observed. Case 6 was one of fibrous replacement of the articular cartilage with complete fibrous ankylosis of the joint. In Case 7, a thick, purulent exudate was found in the joint space. Microscopically numerous pus cells and marked degenerative changes of the cartilage were present.

Macerated Series

Fifty-two specimens were macerated, thirty-five males and seventeen females. Osteo-arthritic changes, varying from small osteophytes about the margin of the joints, to large, over-hanging osteophytic masses with incipient or complete fusion of the joint, were found in thirty-two of the thirty-five male specimens, or in ninety-one and four-tenths per cent.; and in nine of the seventeen female specimens, or fifty-three per cent. Bony ankylosis, varying from the slight to the advanced or completely ankylosed stage, was found in eighteen of the thirty-five males, or in fifty-one and four-tenths per cent.; but was present in only one woman, or in five per cent. The bony changes found during the different decades are shown in Table I. (See Figures 7, 9, and 10.)

FIG. 7

Macerated specimen—male—age 64. Front view of right sacro-iliac joint.

At upper end is a large osteophyte extending from ilium to sacrum, ankylosing the joint.

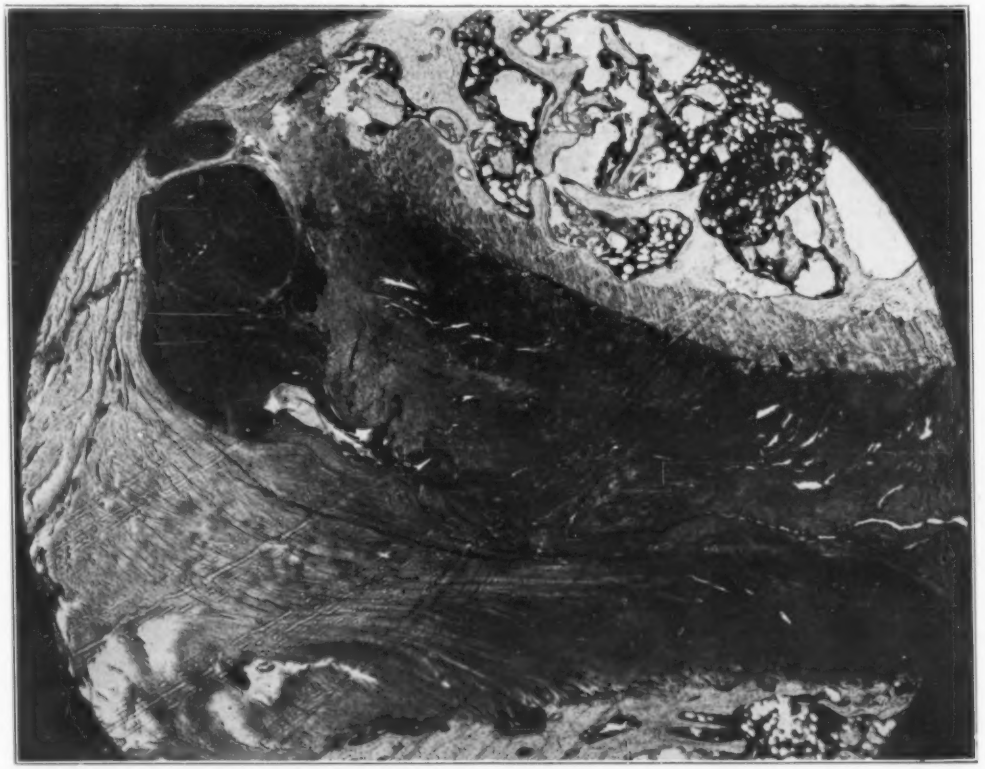

FIG. 8

Photomicrograph—female—age 68—Case 3. Group III. Bony ankylosis and fibrous replacement of articular cartilage.

At the left a thick bony deposit is seen over the anterior aspect of the joint space. Gelatin section, stained with hemotoxylin eosin. × 20.

Comparison of Findings

A comparison of the macerated specimens with those of the fresh specimens in this group shows similar results. The degenerative changes of the articular cartilage precede the osteo-arthritic changes about the joint. It seems clear that the osteophytic formations follow degeneration of cartilage. This is the prevailing opinion among pathologists and was discussed by the writer in a paper on spondylitis deformans[26].

SUMMARY OF GROUP II.

1. Pathologic changes of the articular cartilages were found in the gross in ninety-one per cent. of the male joints, and in seventy-seven per cent. of the female joints. Microscopically, pathologic changes of varying degrees were noted in all the sections. In two cases a purulent exudate was found in the joints.

2. In males, mobility was present to a slight degree up to the fourth decade and imperceptible in most cases thereafter. In the female, slight motion was obtainable in most of the specimens up to the fifth decade, and in some slight movement could be elicited up to the sixth decade.

3. Osteo-arthritic changes were found in ninety-one per cent. of the male and in fifty-three per cent. of the female joints.

4. Bony ankylosis was found in fifty-one per cent. of the male joints and in five and eight-tenths per cent. of the female joints.

GROUP III. 103 Cases—Ages Sixty and Above.

The progressive degenerative changes noted in Group II were found in the cases of this series. The changes were as a rule very marked;

TABLE II

MACERATED SPECIMENS—GROUP III

Osteo-arthritic Changes and Bony Ankylosis of the Sacro-iliac Joints

Age	Total No. Cases	Osteophytes Around Joint Margins				Bony Ankylosis			
		Beginning	*Moderate*	*Advanced*	*Per cent.*	*Beginning*	*Moderate*	*Advanced*	*Per cent.*
				MALES					
60-69	14	1	11	2	100	6	3	2	78
70-79	10	1	5	4	100	3	2	3	80
80 and up	4	0	2	2	100	0	1	3	100
				FEMALES					
60-69	7	2	4	1	100	2	0	0	29
70-79	11	2	8	1	100	2	2	0	36
80 and up	5	1	4	0	100	1	0	0	20

fibrous replacement of the articular cartilages with fibrous and bony ankylosis were very common. The following cases illustrate the typical joint findings in this group.

CASE 1.—Male—Age sixty-two, well developed and markedly jaundiced.

Anatomic diagnosis: Carcinoma of the common bile duct with metastases.

Macroscopic Examination: No motion was present. Both joint surfaces were deeply icteric; the surfaces were rough and very irregular; coarse fibrous strands passed from surface to surface. Around the anterior margins of the joint osteophytes were present.

Microscopic Examination: Many sections were examined. These showed marked irregularities and fibrous thickening of the articular surfaces. There were many irregular areas of degenerated cartilage. Fibrous replacement of the articular cartilages was more marked over the ilium.

FIG. 9

Macerated specimen—male—age 70.
Front view of sacrum and sacro-iliac joints. Solid bony ankylosis over upper half of right joint. Note beginning fusion over upper part of left joint.

Sections stained with Sudan III showed the presence of large amounts of fat in the degenerated areas. The interosseous ligament presented numerous deep orange-stained globules, showing the presence of a great deal of fat within its meshes.

CASE 2.—Male—Age sixty-seven.

Anatomic diagnosis: Bronchopneumonia and gout.

Macroscopic Examination: In all the joints of the body a thick, heavy white, chalky layer was found over the articular surfaces. The sacro-iliac joints were firmly ankylosed anteriorly by overbridging osteophytes. Posteriorly a small remnant of articular cartilage was seen covered with a thick, white, chalky deposit.

Microscopic Examination: Section showed complete fibrous replacement of the articular cartilage. Anteriorly, complete bony ankylosis was present.

CASE 3.—Female—Age sixty-eight.

Anatomic diagnosis: Cerebral hemorrhage.

Macroscopic Examination: There was no motion of the sacro-iliac joint. Firm bony ankylosis was present. A cross section of the joint showed both articular surfaces covered with yellow, thick, calcareous plaques. The joint surfaces were very narrowed and indistinct. Anteriorly bony deposits or osteophytes bridged the joint.

Microscopic Examination: Sections showed fibrous replacement of the articular cartilage throughout. Its free surfaces were markedly irregular. Anteriorly, the joint space was closed by a bony deposit. At the cartilage-bone junction, vascularization and, in places, vessel invasion were noted. (See Figure 8.)

CASE 4.—Female—Age eighty.

Macroscopic Examination: No motion was present. Bony ankylosis present. Both articular surfaces covered with yellow, calcareous plaques. Anteriorly bony fusion was present.

Microscopic Examination: Sections showed marked degenerative changes of both articular surfaces. Fibrous replacement was seen throughout. The free surfaces were markedly irregular and bound by fibrous connective-tissue bands. Anteriorly bony deposits fused the joints. Sections stained with Sudan III showed a thick, fatty, degenerated layer over the free surface of the cartilage.

Macerated Specimens

Osteo-arthritic manifestations from slight to a marked degree were found in all the specimens of this group. In some specimens the osteophytic formations around the margin of the anterior aspects of the joints were very rough, pointed, and sharp. In others these osteophytes were very large and fused the joints firmly. Bony ankylosis in this series was found in twenty-three of the twenty-eight male specimens, or in eighty-two per cent.; and in seven of the twenty-three female specimens, or in thirty per cent. Table II shows the degree and extent of osteo-arthritic changes as well as bony ankylosis in the male and female specimens.

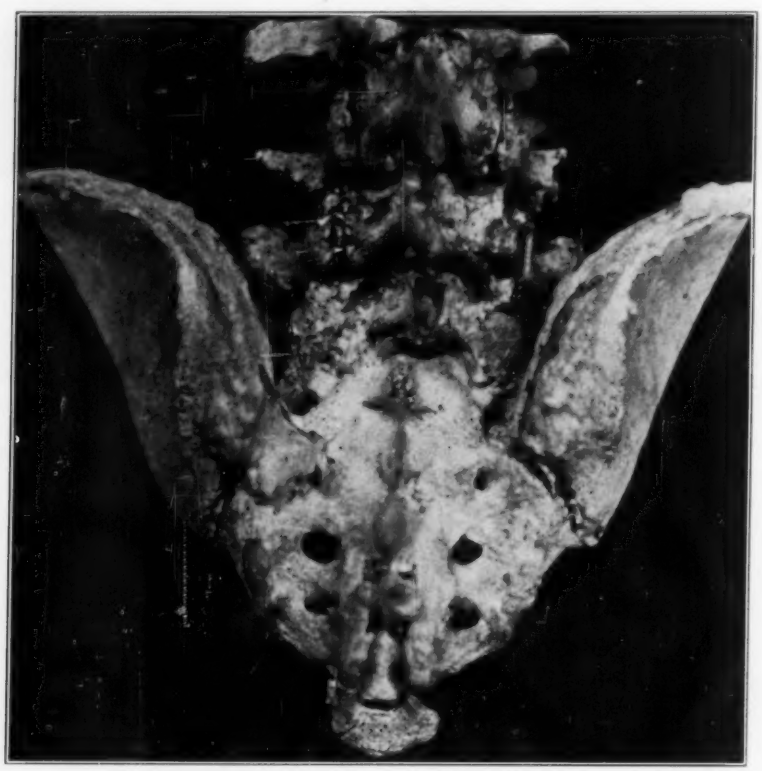

FIG. 10

Macerated specimen—male—age 84.
Posterior view of sacrum and sacro-iliac joints. At left is a thick bony deposit over lower part of left joint.

SUMMARY OF FINDINGS OF GROUP III.

1. Degenerative changes of the articular cartilages in the fresh specimens were found in all of the sacro-iliac joints.

2. Osteo-arthritic changes as seen in the macerated specimens were also present in all the cases. These changes were definitely more marked in men than in women.

3. Bony ankylosis was present in eighty-two per cent. of the male joints and in thirty per cent. of the female joints.

DISCUSSION

An analysis of the findings in 257 post-mortem examinations brings out the fact that pathologic changes in the sacro-iliac joints are very common. These changes are progressive and increase both in extent and intensity with the age of the individual. Concomitant with the degenerative changes, or following them, is the formation of osteophytes. These osteo-arthritic changes were often seen, particularly in males, in the third decade, and were often unassociated with other arthritic manifestations elsewhere in the body. In advanced life fibrous and bony ankylosis were common. How frequent these changes were, may be seen in Tables I and II. It is, however, important to emphasize that these changes are very common, and were uniformly found after the third decade, and that they were more frequent and extensive in the male.

Barkow[2] in 1841 was the first to note a tendency of the sacro-iliac joints to fuse. He cites two cases, one a man of forty and one over sixty, in whom he found the joint cavities in places completely fused. Leri[27] in a series of 100 cases (forty-three pathologic specimens from Dupuytren's Museum; and fifty-seven from Broca's Museum, anthrapologic specimens taken from normal subjects of the various races) found arthritic changes in sixteen sacro-iliac joints or in thirty-seven per cent. of the first group. In the fifty-seven normal cases, only three or five per cent. showed early changes in the sacro-iliac joints. In none of the cases was bony ankylosis noted. Brooke[15] in an examination of 200 anatomic specimens, of which ninety-five were males and 105 females, found thirty-seven per cent. of all male joints completely immovable and ankylosed. In none of the female patients was bony ankylosis present. He concludes thereby that ankylosis of the sacro-iliac joints in advanced life, is confined strictly to the male sex. His conclusions are not entirely confirmed by the author's findings.

The early onset of osteo-arthritic changes and bony ankylosis seems to be closely bound to the mechanics of the sacro-iliac joints. The position of the articulations between the sacrum and the iliac bones is such as to place them as the only direct connecting link between the trunk and the lower extremities. They are at the place of intersection, where the entire weight of the body is divided and transmitted through the joints to the lower limbs. Pressure of the superimposed body weight, sudden turns or shifts, or any sudden change in position, subjects the joint surfaces to great trauma. As a result of this constant pounding, or pressure effects

upon the articular surfaces, early degenerative and osteo-arthritic changes set in, which eventually lead to bony ankylosis. In the male, where the chief concern is stability, these changes set in early, and in the fifth decade the joints are immovable, and in most cases ankylosed. In the female mobility plays an important part, and as a result osteo-arthritic changes are not as common and bony ankylosis is of infrequent occurrence.

I am happy to acknowledge my indebtedness to Geheimrat Prof. Schmorl who put his material at my disposal, and to Dr. Mayer and Dr. Jaffe who made helpful suggestions while the work was in progress at this hospital.

BIBLIOGRAPHY

1. Meckel, J. F.: Handbuch der menschlichen Anatomie. Halle und Berlin, II, 354, 1816.
2. Barkow: Quoted by Fick.
3. v. Luschka, H.: Die Kreuzdarmbeinfuge und die Schambeinfuge des Menschen. Virchows Arch. f. path. Anat., VII, 299, 1854.
4. Gray, Henry: Anatomy—Descriptive and Surgical. Ed. 1, London, 1858.
5. Gray, Henry: Anatomy of the Human Body. Ed. 21, Philadelphia, 1924.
6. Braus, H.: Anatomie des Menschen. Ein Lehrbuch für Studierende und Ärzte. Berlin, 1921.
7. Heisler, John C.: Practical Anatomy. Ed. 3, Philadelphia, 1923.
8. Berry, Richard J. A.: Practical Anatomy, Vol. II. Melbourne and Sidney, 1922.
9. Testut, Jean Léo: Traité d'Anatomie humaine. Paris, 1889.
10. Rauber und Kopsch: Lehrbuch und Atlas der Anatomie des Menschen. Leipzig, 1929.
11. Morris, H.: Human Anatomy. Ed. 8. Philadelphia, P. Blakiston's Son & Co., 1925.
12. Cunningham, D.: Textbook of Anatomy. Ed. 5, New York, 1925.
13. Rouvière, H.: Anatomie Humaine; descriptive et topographique. Paris, I, 1924.
14. Fick, R.: Handbuch der Anatomie und Mechanik der Gelenke unter Berücksichtigung der bewegenden Muskeln. Jena, Bardeleben, 1911.
15. Brooke, R.: The Sacro-iliac Joint. J. Anat., London, LVIII, 299, 1923–1924.
16. Albee, F. H.: A Study of the Anatomy and the Clinical Importance of the Sacro-iliac Joint. J. Am. Med. Assn., LIII, 1273, 1909.
17. v. Luschka, H.: Die Anatomie des Menschen in Rücksicht auf die Bedürfnisse der praktischen Heilkunde. Tübingen, II, (2), 89, 1863.
18. Meckel, J. F.: Manual of General, Descriptive, and Pathologic Anatomy. Trans. from the German into French by A. J. L. Jourdan and G. Breschet and from French into English by A. Sidney Doane. Philadelphia, III, 1832.
19. Köllicker: Quoted by Fick.
20. Sansten: Quoted by Albee.
21. Slocumb, L. and Terry, R. J.: Influence of the Sacrotuberous and Sacrospinous Ligaments in Limiting Movements at the Sacro-iliac Joint. J. Am. Med. Assn., LXXXVII, 307, 1926.
22. di Gaspero, H.: Über die affektionen des Ileosakralgelenkes. Ztschr. f. d. Ges. Phys. Therapie., XXXIII, 40, 1927.
23. Goldthwait, J. E. and Osgood, R. B.: A Consideration of the Pelvic Articulations from an Anatomical, Pathological, and Clinical Standpoint. Boston Med. and Surg. J., CLII, 593, 1905.
24. Meyer, G. H.: Der Mechanismus der Symphysis sacro-iliaca. Arch. f. Anat. u. Physiologie (Leipzig). I, 1, 1878.
25. Klein, G.: Zur Mechanik des Ileosacralgelenkes. Ztschr. f. Geburtsh. u. Gynakol., XXI, 74, 1891.
26. Sashin, D.: Spondylitis Deformans. In press.
27. Leri, A.: Etudes sur les Affections de la Colonne vertébrale. Paris, Masson et Cie, 1926.

FRACTURES OF THE HUMERUS TREATED BY MEANS OF THE HOKE PLASTER TRACTION APPARATUS

BY LAWSON THORNTON, M.D., ATLANTA, GEORGIA

Fifteen years ago Dr. Michael Hoke devised a method of treating fractures of both the upper and lower extremities, which he has called plaster traction. The method has never been published, but has often been demonstrated to those who have visited this Clinic. At the present time the method is essentially the same as originally designed. Its efficiency has become more appreciated, and its applicability to various bone and joint conditions has broadened its usefulness, so that it is now a standardized procedure. In this article only the fractures of the humerus will be considered.

The principle of the apparatus, as applied to the upper extremity, is that traction is made on the extremity and counter-traction against the side of the body. It consists of a plaster-of-Paris arm spica with ratchet windlass attached to the arm portion of the cast, plus either adhesive tape skin traction or Steinmann pin for skeletal traction. If adhesive tape traction be used, a single broad strip of adhesive is placed to lap over the dorsum, lateral and inner surfaces of the upper arm up to a point below the site of the fracture. The loose end of the adhesive tape has previously been folded

FIG. 1

Photograph of a patient with Hoke plaster traction apparatus applied.

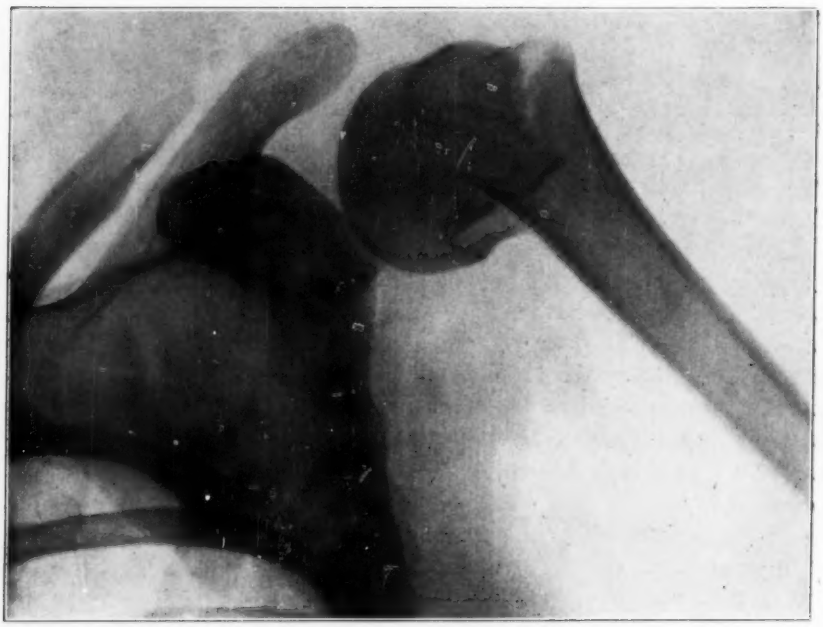

FIG. 2

Case 1. Fracture of neck of humerus.

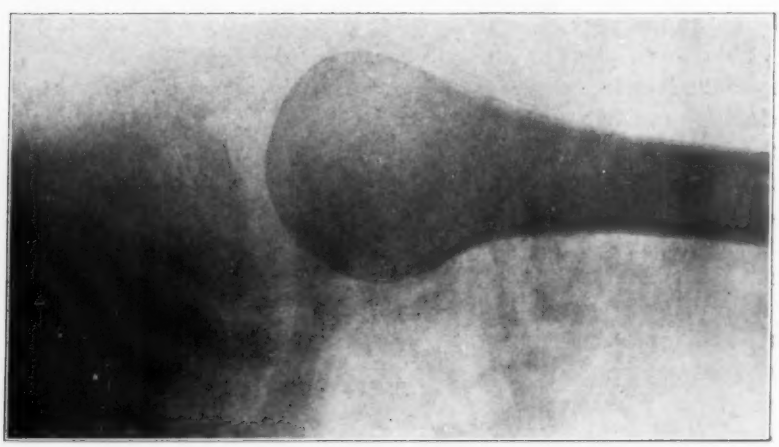

FIG. 3

Case 1. Roentgenogram of same humerus taken immediately after applying Hoke plaster traction apparatus. Reduction without anaesthesia.

FIG. 4

Case 2. Roentgenogram of comminuted fracture of the head of the humerus.

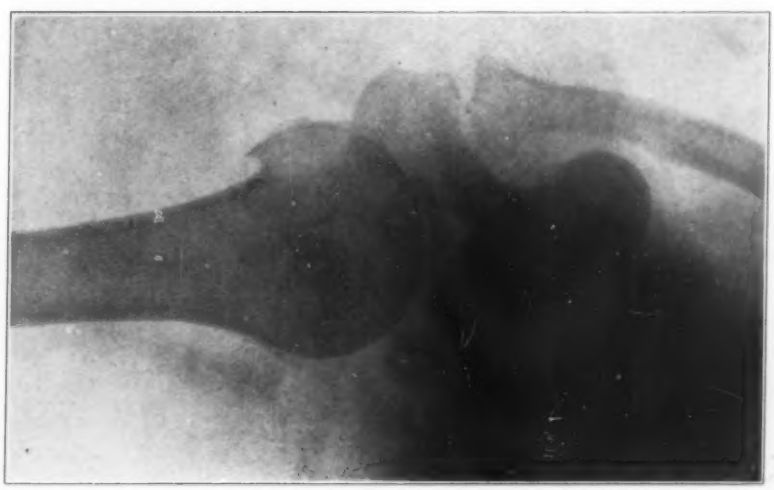

FIG. 5

Case 2. Roentgenogram of the same humerus immediately after applying the Hoke traction apparatus.

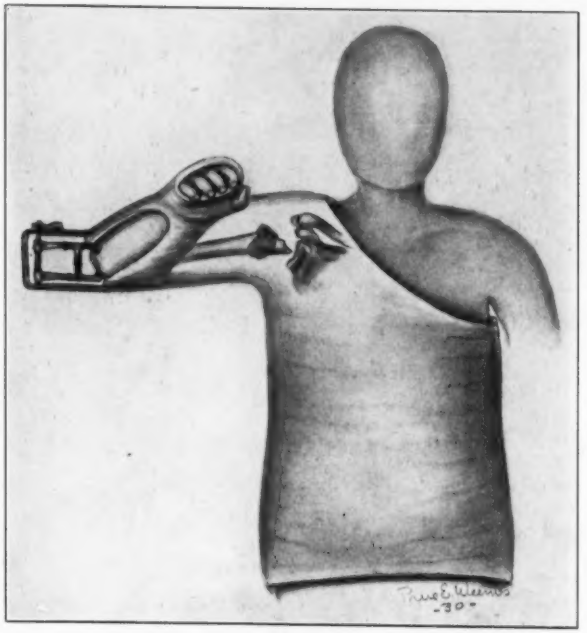

FIG. 6

Case 2. Drawing illustrating Hoke plaster traction splint applied in a case of comminuted fracture of the head of the humerus.

FIG. 7

Case 2. Drawing illustrating reduction of comminuted fracture of the head of the humerus.

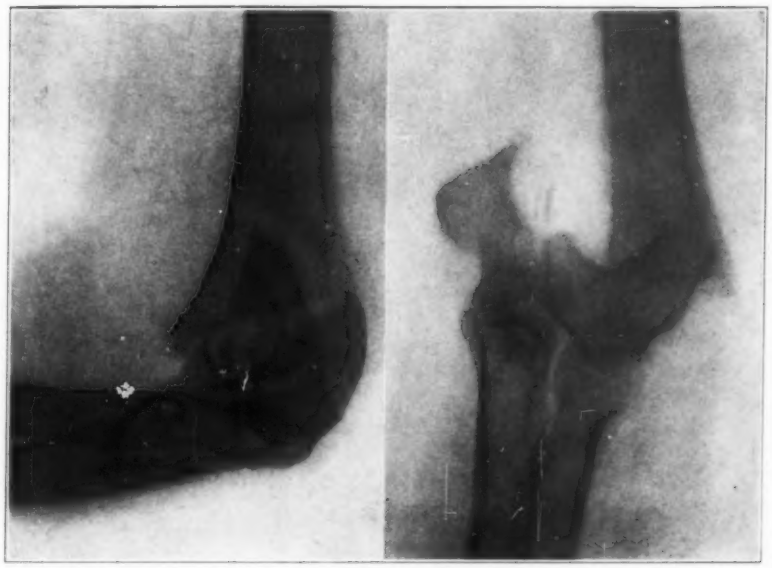

FIG. 8

Case 3. Roentgenogram of a comminuted fracture of the distal end of the humerus.

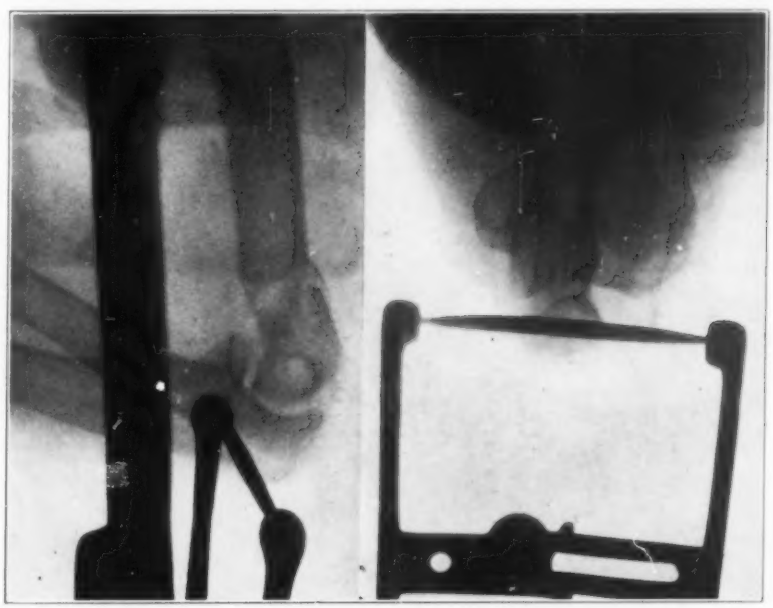

FIG. 9

Case 3. Roentgenogram of the same comminuted fracture immediately after the Hoke plaster traction apparatus was applied. The Steinmann pin appears in the picture.

FIG. 10

Case 3. Drawing showing the Hoke plaster traction apparatus applied with Steinmann pin through the olecranon process of the ulna.

back upon itself to a point just above the elbow, and is trimmed with scissors to the width of the windlass bar. The loose end of adhesive is then tucked into the sleeve of the stockinet, so that the arm cast may be applied over it and it may be withdrawn later through a window cut in the forearm portion of the cast, as is shown in the photograph (Fig. 1). This adhesive tape will be attached to the windlass when the traction splint is attached to the upper arm cast.

If skeletal traction be the method of choice, a Steinmann pin is placed after the window is cut in the cast. Skeletal traction is necessary in comminuted fractures of the upper and lower ends of the humerus.

FIG. 11

Case 3. The end result.

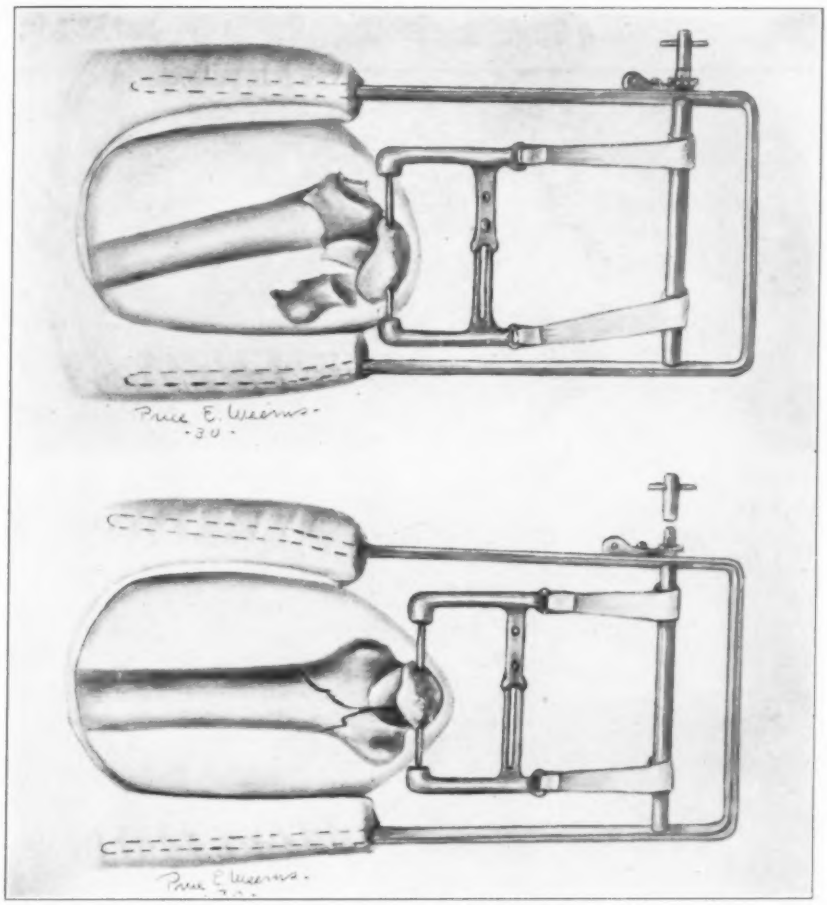

FIG. 12

Case 3. Drawings showing details of the ratchet windlass, Steinmann pin through olecranon, and the comminuted fracture of the distal end of the humerus before and after reduction.

Fractures of the humerus, treated by this method, usually do not require anaesthesia. Local anaesthesia or a brief gas anaesthesia is used for introducing the Steinmann pin.

It is our custom to reduce certain types of transverse fractures of the humerus by manipulation, and then apply a body-arm spica cast. However, we take the precaution of applying an adhesive strip to the skin, just as is described above, and should the fragments not remain in position, traction can be applied by cutting a window and attaching the traction splint, the fracture being then easily reduced.

The accompanying photograph, roentgenograms, and drawings illustrate the method as employed in different types of fractures of the humerus.

THE MECHANICAL REDUCTION OF RECENT FRACTURES UNDER THE CONTROL OF THE DOUBLE SCREEN (ANTEROPOSTERIOR AND LATERAL PLANES)

BY GEORGES PASCALIS, M.D., PARIS, FRANCE

During the past ten years I have reduced all fractures which have come under my care with the control of a radiographic screen. I have found this method most satisfactory, and resulting in a greatly lessened number of open operations. This method, however, has its limitations, for the reduction has been limited to the use of the screen in one plane only; and to verify the reduction in profile, it has been necessary to change the position of the patient, incurring the risk of displacing the primary reduction of the fragments.

The method has now been improved, so as to remedy this defect, by the use of a double screen and of a double light, permitting the reduction by views in both the anteroposterior and lateral planes. It is the application of a general principle to a special purpose, and may be used also in searching for foreign bodies, in examination of the lungs, gastro-intestinal tract, etc.

FIG. 1

Double screen (Bouchacourt). *1.* For the anteroposterior view. *2.* For the lateral view. *3.* The mirror which places the image of the lateral view on the horizontal panel.

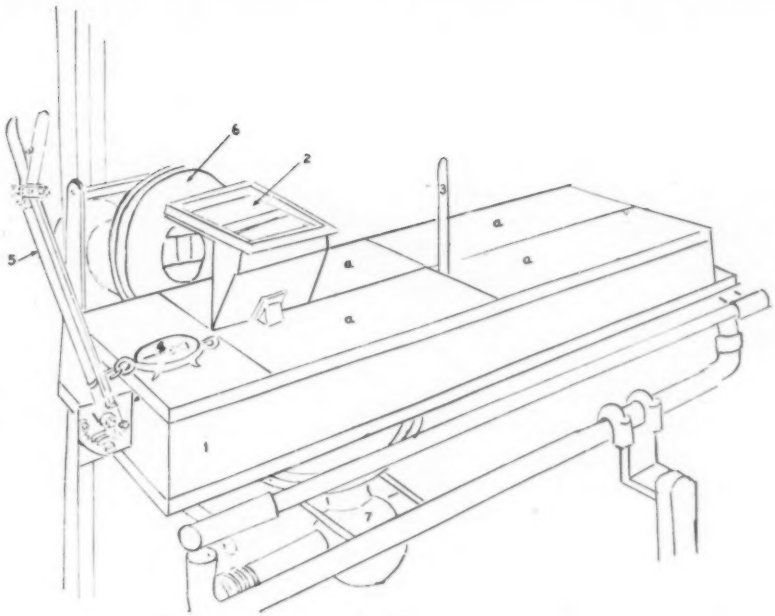

FIG. 2

The author's apparatus for the reduction of recent fractures. *1*. The compartment with its four movable shutters (*a*). *2*. The double screen. *3*. The fixation rod. *4*. The dynamometer. *5*. The reducing tractor. *6*. The lateral tube. *7*. The lower tube.

The apparatus has two parts,—the radioscopic and mechanical.

A. *The radioscopic portion* consists of:

1. A screen, with two glass plates, placed at right angles, so arranged as to give two images,—a horizontal, the anteroposterior view; and a vertical, the lateral view. To the latter is added a mirror, placed at an angle of forty-five degrees, which allows the two views to be seen at the same time.

2. Two x-ray tubes, placed one under the part to be examined, the other at the side. These are connected to the same generator, and their rays cross at right angles at the level of the fracture.

B. *The mechanical portion* consists of a wooden box, placed horizontally on the x-ray table, and is of the following construction: The height is fourteen centimeters; in the top are four movable shutters, and at the lower end is placed a reducing tractor, with a screw mechanism which allows an instantaneous displacement. The tractor is constructed on the principle of an automobile brake, and can exert a considerable degree of force. To the lever is attached by a chain a dynamometer, with a radium dial to allow the operator to read the record in the dark.

Finally, there is fixed in the table a vertical, metal, padded rod which serves to immobilize the patient, either at the level of the perineum or of the axillae, according to the location of the lesion.

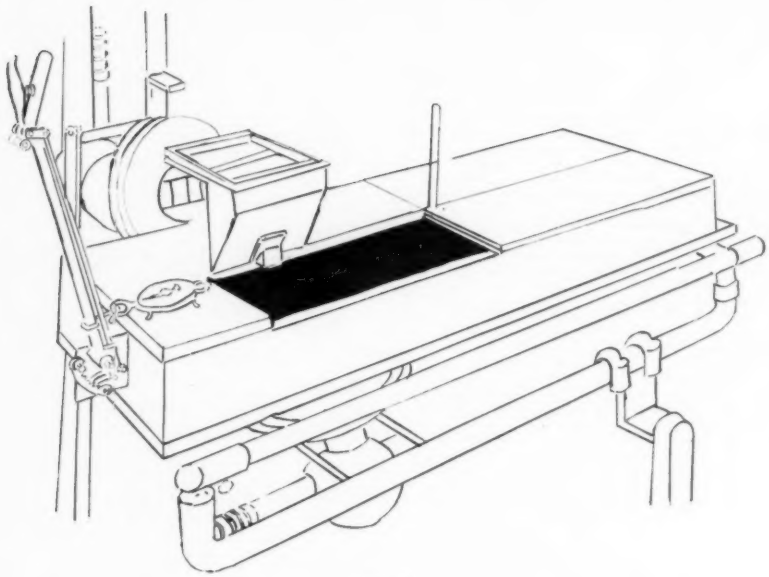

FIG. 3

The apparatus showing one shutter withdrawn to allow application of a plaster cast following reduction.

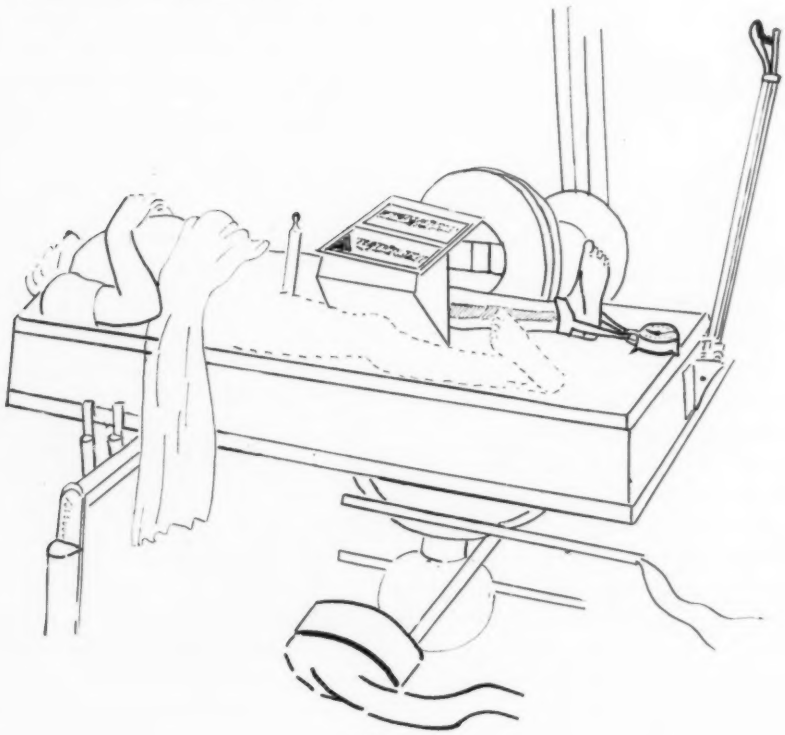

FIG. 4

Showing the patient in position with traction and peroneal countertraction.

APPLICATION

The application of the apparatus is simple. For example,—in a fracture of the leg, the patient, under anaesthesia, is placed on the table with the leg in line with the axis of the tractor, resting on a movable shutter; the perineum is pressed against the fixation rod; the foot is attached to the tractor, with the dynamometer in position, by cloth strips, one passing over the instep, another over the hollow of the heel, and the third under the foot. The screen is placed over the fracture; the assistant is ready to manipulate the lever. With the application of the traction, the surgeon can observe the result; and by lateral pressure, torsion, etc., manipulates the fragments into place. When there is difficulty in the reduction, he can by means of the double screen detect the obstacle and, by eliminating it, can see the fragments slip into place.

APPLICATION OF THE RETENTION APPARATUS TO THE LIMB

As soon as the anatomical reduction is accomplished, the tractor is fixed in its position to maintain the extension on the limb.

If an ambulatory apparatus is to be used, which does not require change of position of the limb, there is placed under the leg, before the operation, a Scultet bandage (Fig. 5), which is then secured quickly in place. If one plans to use a plaster gutter or a circular plaster—which latter I prefer—the shutter under the leg is withdrawn and the bandage is easily applied over a jersey previously put in place. It is desirable to work quickly in order not to prolong the traction, and the operation can be hastened by adding to the plaster five to ten per cent. of a saturated solution of potassium sulphate. The drying will be rapid, without destroying the strength of the apparatus. During this brief time the operator, by use of the screen, can observe whether the fragments have moved and can make any correction necessary. This all may be accomplished in less than ten minutes, and within two hours the patient may be placed in his own bed.

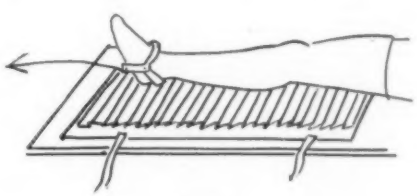

FIG. 5

The Scultet bandage. This is composed of overlapping bands of cloth. When the ambulatory apparatus is in place, the bands may be lowered on the plaster while it dries and then the whole may be wrapped in the cloth and secured by two wooden splints. By elevating the limb the bandage is applied without pain.

In the case of a fracture of the upper extremity the process is the same but more simple, and the author's model of 1926, which is shown in the figures, can be used. It allows the correction of the two usual deformities, —angulation, by carrying the lower fragment into abduction and extension; and overriding, by using countertraction on the two fragments by one movement.

RESULTS

This method and apparatus have been successfully used in a large number of difficult cases, and have in many cases relieved surgeons from employing the open method. They have also been used in the reduction of malunited fractures of several weeks' duration. In my opinion, eighty to ninety per cent. of the fractures now operated upon can in the future be reduced by the use of the double screen.

The method of placing fractures in temporary fixation for several hours, until the surgeon finds time to examine and reduce, is to be condemned. The oedema, the blebs, etc., have had time to appear and the

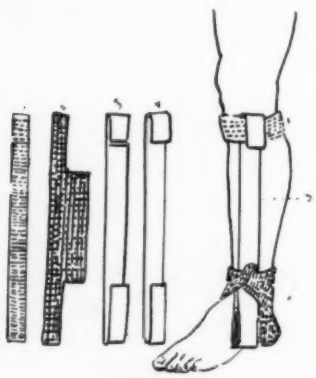

FIG. 6

Ambulatory apparatus as described by Delbet. Two supports (*béquillons*) with twenty-four thicknesses of plaster bandage are used on the lateral aspects of the leg and are doubled back at the level of the malleoli. Two collars of the plaster bandage make these secure at the level of the tibial condyles and at the base of the malleoli.

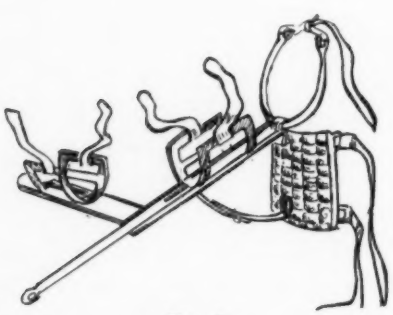

FIG. 7

The author's apparatus for the reduction of fractures of the humerus.

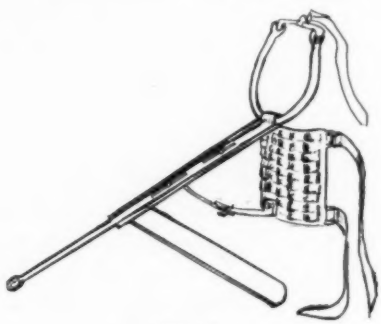

FIG. 8

The author's apparatus without the arm rests. It is composed of: (1) a triangle, with a variable opening which, in abduction, permits the lower fragment to be brought in line with the upper fragment and held there; (2) a fork, resting on the brachial splint and sliding on it as an axis. Constructed of slightly malleable copper, it rests at the top on the coracoid process in front and the spine of the scapula behind. It thus permits correction of overriding.

FIG. 9

Apparatus showing the triangle and the fork separately.

muscles are contracted, all of which markedly complicates the final treatment. A fracture should be regarded as a case of emergency, as is a strangulated hernia or an acute appendix. When this is generally recognized, the reduction and application of the apparatus will gain in simplicity and the results will be of another quality. Fractures occurring so frequently in the working class, there exists a social question which cannot be disregarded.

POSITION OF IMMOBILIZATION

In spite of the aid given by the radiograph, we continue to immobilize fractures in fixed positions. The peculiar positions often used in accepted methods are wrong, and should be regarded as responsible for many of the sequelae,—stiffness, oedema, circulatory disturbances, etc.—which produce about the synovial sheaths of the tendons the deformities which interfere with function.

FIG. 10

Apparatus in position. A cord attached to the end of the handle of the fork runs on a pulley fixed at the angle. It lets down the lower end by direct action and raises the upper end by reflex action, and thus places them end to end.

The method of treatment by the double screen has shown the advantage of breaking with tradition and of immobilizing in normal attitudes, which aids in rendering the immobilization more comfortable to the patient and shortens the after-treatment. The neighboring articulations rapidly regain their function, and there is not seen the oedema nor the circulatory disturbances which the ambulatory method has, on its part, greatly diminished.

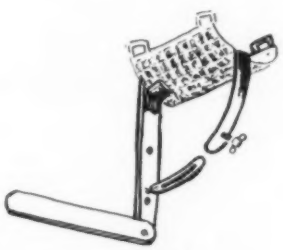

FIG. 11

The triangle taken apart. Showing the mechanism which allows the variation of the degree of abduction.

FIG. 12

Showing the pulley fixed at the level of the elbow.

PROTECTION

A method which uses the x-ray is not without risk to those employing it. If this means gives to the patient a safe cure and the avoidance of operation, it is the duty of the surgeon to protect himself against the danger of its use. The apparatus which will be put to this use in the future will give to him this protection as much as possible. Meanwhile he should bear in mind the added danger from exposure to the two tubes simultaneously in action, should resort to protection by special gloves, apron, etc., and avoid contact with the direct rays.

FRACTURE OF THE SUPRACONDYLOID PROCESS OF THE HUMERUS

Report of a Case

BY HENRY J. LUND, M.D., OAKLAND, CALIFORNIA

A rather unusual case of bilateral supracondyloid spurs with fracture of the spur on the left side was recently seen by the writer.

F. C., male, age twenty-one, was seen on August 2, 1929, complaining of:

(1) A marked point of tenderness just above the median epicondyle of the left humerus.

(2) Severe pain at the same point upon motion of the forearm, particularly rotation.

(3) Weakness of grip together with intermittent severe pains extending from the elbow along the radial border of the forearm into the thumb, index, and middle fingers.

One week prior to the date of examination, he was lifting down some cases of merchandise when he struck his left arm against an adjacent box. The blow was minor in nature; but he felt a sharp, sudden pain extending from the elbow down into his fingers, together with transient numbness. Three days later he noted weakness of his hand together with pain and local tenderness. He denied previous injuries to this member.

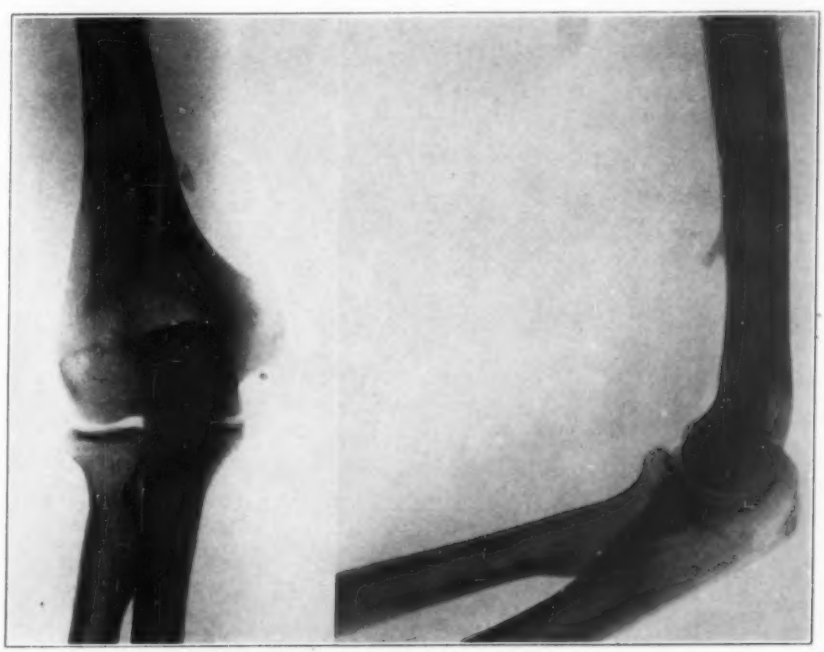

FIG. 1

F. C., male, age 21. Supracondyloid spur, left humerus. Film shows fracture near base of spur.

Examination showed no external evidences of skin injury. There was present a marked point of tenderness along the medial and anterior border of the left arm about four finger-breadths above the elbow. Pressure at this point caused radiating pain to extend into the thumb, index and middle fingers. Flexion and extension of the forearm caused slight pain at the same point. Rotation, particularly supination, caused severe pain at the site of trauma. Grip registered 50 as compared to 124 on the right side. No muscle atrophy or fibrillary twitchings were noted. There was present a hyperaesthesia over the radial half of the palm, flexor surfaces of the thumb, index and middle fingers, and the dorsum of the terminal phalanges of the same fingers. No vasomotor changes were noted.

Examination of the opposite or right elbow revealed a small mass of bony consistency along the medial and posterior border of the arm about one inch proximal to the elbow; otherwise this extremity was normal.

Roentgenograms showed definite bony spurs along the medial and posterior borders of both humeri about one inch proximal to the medial epicondyle. The spur on the left side presented a line of lessened density running transversely through it near its base, the distal fragment being separated from its parent bone and indicating that fracture had occurred.

Diagnosis: Congenital supracondyloid processes of the humerus, bilateral, with fracture of the process on the left side and subsequent pressure upon the median nerve resulting in a causalgia.

Treatment: The forearm was carried in a sling for four weeks. During that period galvanism and sedative diathermy were given. The question of cutting down upon the spur and removing it was discussed but deemed inadvisable due to the danger of increasing the median nerve causalgia, the median nerve being very susceptible to prolonged pain after manipulation.

By September 4, 1929, six weeks after the injury, the tenderness had greatly receded.

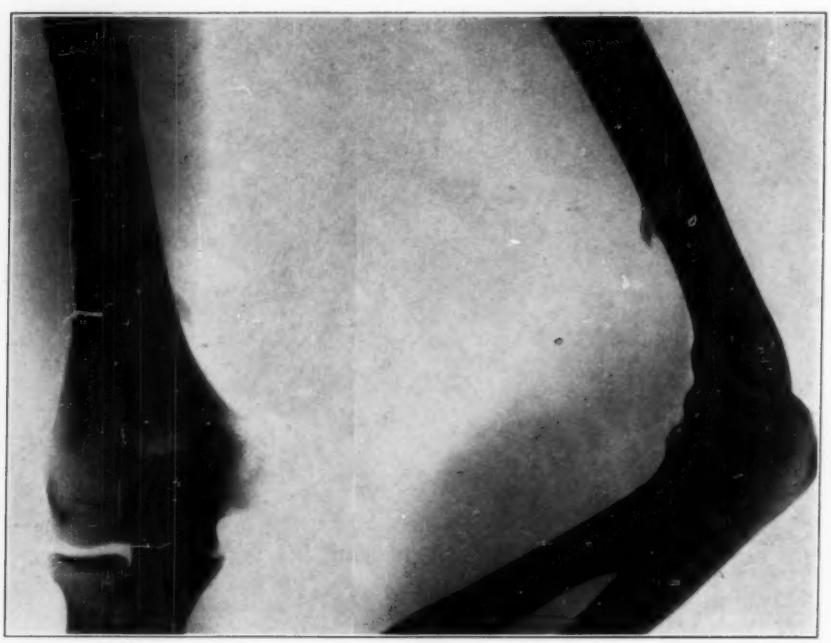

FIG. 2

F. C., male, age 21. Supracondyloid spur, right humerus.

Grip had improved. Radiating pain was felt only at the extremes of rotation. Examination on the date of discharge, October 11, 1929, or eleven weeks after the injury, showed no pathologic signs present. Both processes were easily palpable. The patient had no complaints. Roentgenograms showed the fracture line to have been completely obliterated.

Anatomy: The supracondyloid process of the humerus is described by Quain as a small hook-like process with its point directed downwards and inwards and found in front of the medial epicondyloid ridge. From its extremity extends a fibrous band which in rare cases may be ossified. This band extends to and often connects with the medial epicondyle. Through the arch thus formed passes the median nerve, often accompanied by the brachial artery or a large branch of it. A considerable number of the pronator teres fibers are anchored to the process or to the fibrous band which extends to the medial epicondyle. Its point of origin is given by Testut as seventy-one to seventy-three millimeters above the lowest point of the inner border of the trochlea. The process varies in extent from a compressed prong twelve millimeters long to a small sharp projection in the middle of a prominent ridge. It is frequently prolonged into an arch by ossification of a fibrous band which extends from the tip of the process to the medial epicondyle. One such specimen of a complete bony arch has been described by Dwight, and through this arch passed the median nerve and brachial artery.

Incidence: The frequency of the process, including those three to four millimeters high, is given by Terry as one per cent. The spurs are seen more frequently in females than males. The frequency in the negro is said to be one-tenth that in the white race (Terry). In fifteen described cases eight were left, five right, and two bilateral.

SUMMARY

1. The supracondyloid process of the humerus is a congenital anomaly found in slightly less than one per cent. of adult humans.

2. It arises from the medial and anterior surface of the humerus seventy-one to seventy-three millimeters above the lowest point of the inner border of the trochlea.

3. The median nerve and brachial artery pass directly under the process and are in close apposition with it.

4. The process may be fractured and give rise to symptoms of a median nerve causalgia. A case of this type is reported.

5. The treatment of choice in cases of fracture of supracondyloid spur is absolute rest with early physiotherapy. Surgical removal should only be attempted when a prolonged causalgia results.

BIBLIOGRAPHY

1. Dwight, T.: A Bony Supracondyloid Foramen in Man. With Remarks about Supracondyloid and other Processes from the Lower End of the Humerus. Am. J. Anat., III, 221, 1903.

2. Hrdlička, A.: Incidence of the Supracondyloid Process in Whites and Other Races. Am. J. Phys. Anthropol., VI, 405, 1923.
3. Terry, R. J.: The Supracondylar Process. Am. J. Anat., I, 509, 1901–2.
A Study of the Supracondyloid Process in the Living. Am. J. Phys. Anthropol., IV, 129, 1921.
On the Supracondyloid Variation in the Negro. Am. J. Phys. Anthropol., VI, 401, 1923.
4. Struthers, J.: On the Processus Supracondyloideus Humeri of Man. Trans. Internat. Med. Cong., London, I, 148, 1881.
5. Heath, M.: Case of Supracondylar Process of the Humerus. Trans. Med. Soc., London, XXXIV, 404, 1911.
6. Testut, L.: L'Apophyse Sus-épitrochléenne chez l'Homme. (Vingt-deux observations nouvelles.) Internat. Monatschr. f. Anat. u. Physiol., VI, 391, 1889.
7. Quain: Handbook of Anatomy. Ed. II. Vol. I. Osteology. London, Longmans, Green and Co., 1915.

EWING'S TUMOR (ENDOTHELIAL MYELOMA)

Report of an Atypical Case

BY CHARLES E. SEVIER, B.S., M.D., DENVER, COLORADO

Endothelioma of bone has been the subject of numerous articles, and many observations of this condition have been reported. Ewing[1] has emphasized the fact that our knowledge of this group of neoplasms has progressed slowly because of the difficulty of establishing the exact origin and because other tumors simulate the structure of endothelioma. He concludes, "Yet it is now clear that there is a primary endothelioma of bone with large clear cells and a marked tendency to angiomatous structure".

Ewing, who has done by far the most work on this subject, classifies endothelioma of bone under three separate headings: (1) angio-endothelioma, (2) multiple endothelioma, and (3) diffuse endothelioma, or endothelial myeloma. It is important to recognize and emphasize that it is the third type (diffuse endothelioma, or endothelial myeloma) which constitutes the so called Ewing's tumor.

The purposes of this communication are:

(1) To report an unusual case.

(2) To enumerate the total number of cases of Ewing's tumor reported in the medical and surgical literature up to the year 1929. So far as the author has been able to ascertain from a study of the literature on the subject of endothelial myeloma, this has never been done.

(3) To review and describe the principle features of this neoplasm.

The case reported here occurred in the Colorado General Hospital on the orthopaedic service of Dr. S. Fosdick Jones, and the writer is indebted to him for his courtesy in giving the opportunity of presenting this case and reporting the condition.

CASE REPORT

V. S., a female, aged three years, was admitted September 2, 1926, with the complaint, "My knee hurts".

Family History: The father has had active pulmonary tuberculosis for the past three years. The family history is otherwise negative. There are two other children, living and well.

Past History: The patient has always been normal and well until the onset of the present trouble.

Present History: (Obtained from the patient's mother). There is no history of injury. One week previous to admission, a limp appeared, and the following day the patient complained of pain in the left knee. She was in bed for the next few days, with

restlessness and frequent night cries. The pain disappeared after the rest period, but immediately recurred after the child was allowed to be up.

Physical Examination: Patient is a well developed, well nourished child, walking with a left limp. Upper extremities negative. Right lower extremity normal. With the exception of the left knee, the left lower extremity is normal. *Left knee:* Tissues about this joint are slightly swollen. Knee is flexed at an angle of 165 degrees and can be extended to an angle of 170 degrees; angle of greatest flexion is 85 degrees. Slight increase of local temperature about the left knee. The tissues about the joint are swollen and boggy and are tender to light pressure.

Measurements:

Circumference of the left knee, above patella	7¾ inches
Circumference of the left knee, over patella	8½ inches
Circumference of the left knee below patella	7¼ inches
Circumference of the right knee, above patella	6¾ inches
Circumference of the right knee, over patella	7¾ inches
Circumference of the right knee, below patella	6½ inches
Circumference of the left thigh, 5 inches below anterior superior spine	8 inches
Circumference of the right thigh, 5 inches below anterior superior spine	8½ inches
Circumference of the left leg, 4 inches below mid-patella	7 inches
Circumference of the right leg, 4 inches below mid-patella	7 inches
L. A., measured from left anterior spine of ilium to internal malleolus	18 inches
R. A., measured from right anterior spine of ilium to internal malleolus	18 inches

A provisional diagnosis of tuberculosis of the left knee joint was made, and the patient was recommended for admission to the orthopaedic service of the Colorado General Hospital.

Course in Hospital

The blood examination made September 7, 1926 was as follows:

Hemoglobin (Dare),	79 per cent.
Red blood cells,	4,040,000.
White blood cells,	11,900.
Differential Count:	
Polymorphonuclear neutrophils,	56 per cent.
Small lymphocytes,	43 per cent.
Large lymphocytes,	0 per cent.
Basophils,	0 per cent.
Eosinophils,	1 per cent.
Transitionals,	0 per cent.

Wassermann reaction of blood negative; urine examination negative. The von Pirquet skin test was negative at the end of twenty-four and forty-eight hours. Rectal temperature 99.4 degrees. Pulse 110. Respiration 20.

The roentgenologic report of the left knee by Dr. J. L. Harvey follows: "The epiphyses of the femur and tibia show a normal development for a child of this age. The joint space is cloudy. The epiphyseal borders of the femur are roughened, especially at the internal margin and to less extent at the external margin. Diagnosis: Early tuberculosis of the left knee."

Following the application of traction to the left leg, the muscular spasm and the deformity disappeared at the end of the fifth day, and the patient was allowed home, wearing a light plaster-of-Paris cast. The patient returned to the hospital at regular intervals for observation. On December 30, 1926, a moderately enlarged lymph gland was felt in the left groin. One month later, on removal of the dressing, a small glass marble was found embedded in the cast, pressing against the tissues of the left popliteal space. The skin and subcutaneous tissues in this region were reddened and swollen, and the local temperature showed a moderate elevation.

On January 28, 1927, the patient was admitted to the Children's Hospital on the orthopaedic service of Dr. S. Fosdick Jones. The blood examination at this time was as follows:

Hemoglobin (Dare),	85 per cent.
Red blood cells,	5,300,000.
White blood cells,	23,500.
Differential Count:	
Polymorphonuclear neutrophils,	79 per cent.
Small lymphocytes,	18 per cent.
Large lymphocytes,	2 per cent.
Basophils,	0 per cent.
Eosinophils,	1 per cent.
Transitionals,	0 per cent.

The blood culture showed no growth in dextrose broth at the end of seventy-two hours. Rectal temperature 101 degrees. Pulse 110. Respiration 20. Physical examination negative, except for the condition of the left knee and thigh above described.

The results of the physical examination and laboratory tests led to the diagnosis of tuberculosis of the knee joint, with a deep-seated abscess in the popliteal space. The patient was treated with hot compresses to the knee and confined to bed with the left leg elevated.

The roentgenologic report made February 7, 1927, was as follows: "There is a shadow of a large oval mass, posterior to the knee joint. This is thought to be independent of the joint cavity, but it cannot be stated absolutely that this does not arise from the joint space. The epiphyses show slight roughening, but no breaking down. The joint space is not lessened. Diagnosis: Abscess in soft tissues posterior to knee, probably independent of the joint space."

An exploratory aspiration of the swelling in the popliteal space showed no evidence of pus or fluid.

Figure 3 shows a roentgenogram of the chest taken in February 1927. The shadows seen in the upper mediastinum (right and left) were thought to be due to enlarged tuberculous lymph glands. The areas of calcification seen at the hilus of the right lung and along the course of the right lower bronchus were also interpreted as evidence of an old tuberculosis.

The patient was kept in open air and sunlight during the day, and in a well ventilated room at night. She was given full diet, with added special feeding.

FIG. 1

Anteroposterior view of left knee joint, showing definite area of erosion of the femoral epiphysis, especially at its internal aspect. Notice also cloudiness about the joint.

During the latter part of March, the patient complained of pain in the right ear, and examination revealed a protrusion of the drum membrane. By paracentesis, a few drops of a seropurulent exudate were obtained, a culture of which produced a pure growth of staphylococcus aureus. On April 4, pain developed in the left ear, and an identical pathology to that in the right ear was found.

The patient's general condition was poor, though up to this time no marked change had taken place in the left knee. During the third week in April, the swelling in the popliteal space showed a decided increase in size. While the probability of the existence of an atypical new growth had been considered previous to this time, the diagnosis was now made of a rapidly growing, very malignant tumor. During the third week in April, the mass quickly infiltrated the surrounding tissues, and the overlying skin had a parched appearance. A foul, fungating area of granulation tissue developed in the popliteal space a few days after a small opening in the skin had appeared.

The following roentgenologic report made by Dr. F. B. Stephenson describes the knee joint and surrounding structures as they appeared during the last week of April: "Soft-tissue mass, posterior to the knee joint, protruding backward. The condylar heads show some roughening."

FIG. 2

Roentgenogram of left knee joint taken February 7, 1927, showing roughening of the epiphysis of the femur and swelling of the tissues about the joint. The swelling seen in the popliteal region was thought to be an abscess.

Under light general anaesthesia, a section of the tumor tissue was excised by Dr. S. Fosdick Jones during the first week in May. The microscopic examination of the tissue removed was made by Dr. W. W. Williams. His diagnosis was "Ewing's sarcoma".

Dr. William C. Johnson, Professor of Pathology at the University of Colorado, School of Medicine, has recently reviewed the microscopic sections, prepared in May 1927, from the tumor tissue of this case. He has made the following report:

"Section of tissue obtained from biopsy on tumor of knee. Section shows necrotic material along one side, which is markedly infiltrated with polymorphonuclear leucocytes. The main part of the section consists of large masses of tumor cells. These cells are of medium size, with oval nuclei containing one or more small nucleoli. Mitotic figures are abundant. The cytoplasm of the cells is poorly fixed and has an indefinite ragged outline. The cells are uniform in size. No giant cells are present. The arrangement of the cells shows nothing characteristic. They are in the form of irregular sheets or masses. Dilated capillaries are present through some of the masses. Between the

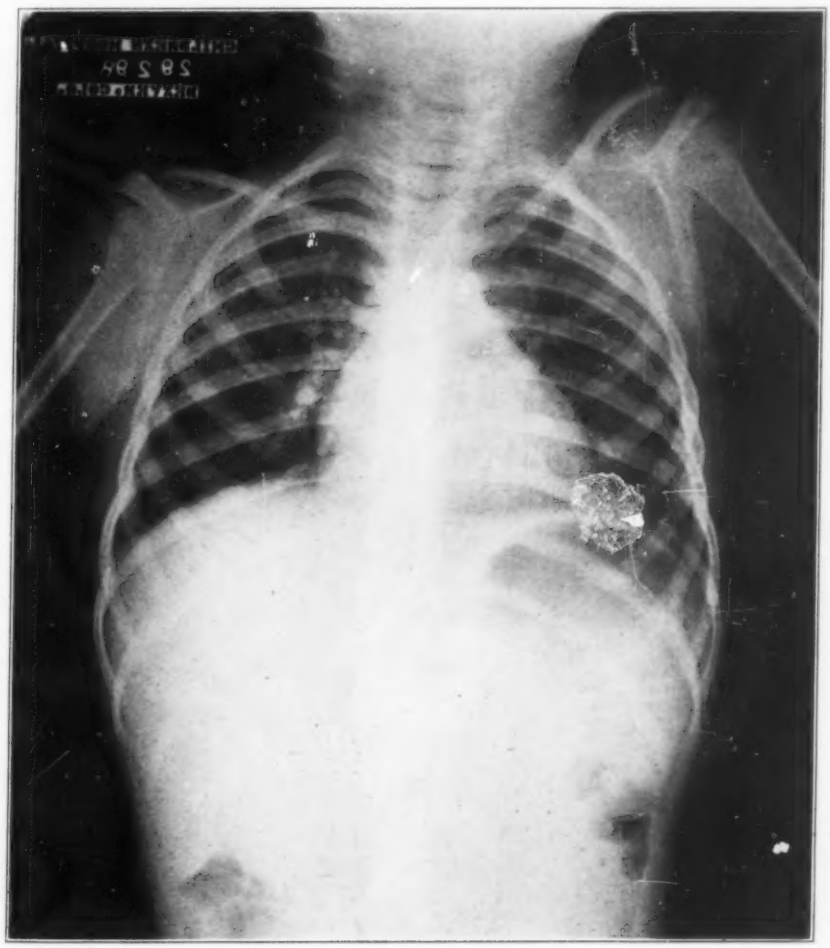

FIG. 3

Roentgenogram of the chest taken in February 1927. Note the shadows in the upper mediastinum and the thickened tissues about the hilus of the right lung and right descending bronchus.

masses of tumor cells are strands of loosely arranged connective-tissue fibers containing many polymorphonuclear leucocytes. Diagnosis: Ewing's sarcoma of bone."

Almost coincident with the recognized and proven pathology of this extremely malignant and rapidly growing neoplasm, definite evidence of metastasis appeared in various parts of the body. The left inguinal lymph glands increased in size rapidly, and the overlying skin ruptured. Pain developed in the shoulders and arms; fine, dry, crepitant râles appeared over both lungs; and the patient developed a non-productive cough. A swelling of rubbery consistency, about the size of a cherry, appeared in the roof of the buccal cavity. This also increased rapidly in size.

Figure 9 shows roentgenogram of the left knee, taken May 10, 1927. Definite metastasis can be seen in the tibia, and the rapid growth of the tumor in the soft tissues is evident.

The roentgenogram shown in Figure 10 was made May 14, 1927. Multiple metastatic areas of disease are shown in the lungs, humeri, and scapulae.

During the last three weeks of May, the patient became rapidly emaciated, refused her food, and remained in a stuporous condition most of the time. The blood examina-

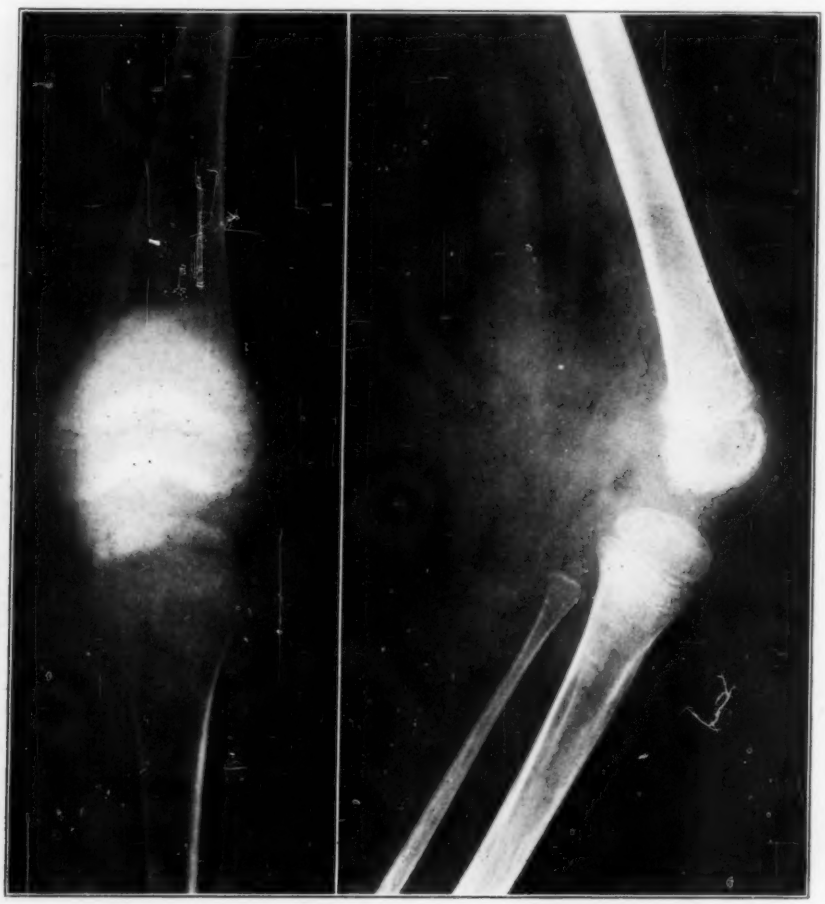

FIG. 4

Roentgenogram showing tumor mass in popliteal space, as it appeared in the last week of April 1927. Note the extensive involvement of the soft tissues compared with the slight erosion of the femoral epiphysis.

tion revealed a marked secondary anaemia (40 per cent. hemoglobin; 3,200,000 red blood cells), and a high leucocytosis (27,000, with 74 per cent. polymorphonuclear neutrophils). The temperature remained at a high level (103.5 degrees), and the pulse was very rapid (140).

Because of the unusual and atypical features which this case presented, the true pathological condition was not recognized until approximately three weeks before the patient died. Almost coincident with the recognition of the correct diagnosis, multiple metastases appeared suddenly throughout the body. The accompanying rapid emaciation, anaemia, hyperpyrexia, and stupor were indicative of an early fatal termination of the disease. Due to this fact, it was not considered wise, at this advanced stage of the disease, to subject the patient to radiation, injections of Coley's toxins, or to radical surgery. The tumor masses of the knee and groin were cleansed frequently with normal saline solution, and dressings were applied as required. Pain was controlled by small doses of codein.

The patient became comatose on May 31, and died June 3, 1927, nine months and one week from the onset of the disease. Autopsy was not permitted.

FIG. 5

Photograph of patient, showing appearance of tumor in left popliteal space a few days after the skin had ruptured. The granulation tissue in the center of the growth soon became a large cauliflower-like mass.

FIG. 6

Photograph of patient, showing tumor of left knee.
Note the parchment-like appearance of the skin.

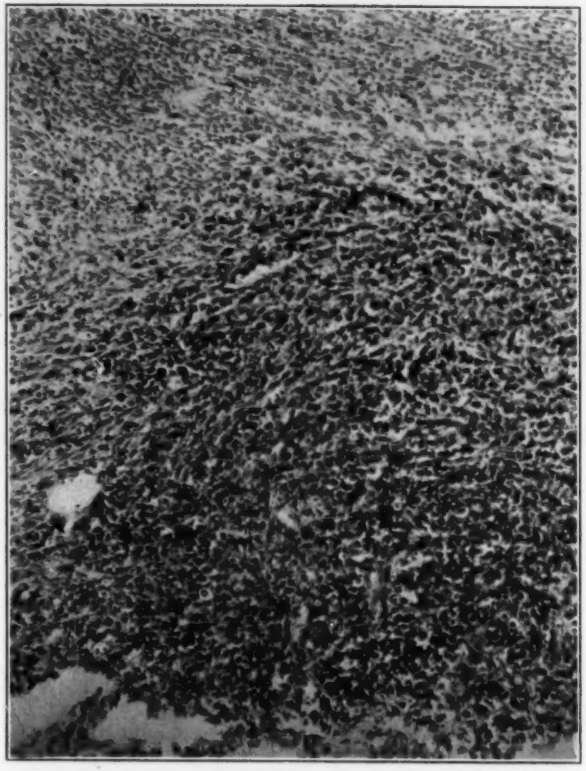

FIG. 7

(Low power). Microscopic appearance of the tumor tissue. Author's case.

FIG. 8

(High power). Showing structure of highly malignant tumor. Author's case.

HISTORICAL DATA (1866–1923, INCLUSIVE)

Lücke[2], in 1866, was the first to describe a tumor resembling endothelioma of bone. In 1868, Kocker[3] reported a pulsating tumor of the frontal and temporal bones, which developed eight months after an injury. Billroth[4] reported a similar case in 1869, and Engelmann[5], in 1871, reported a tumor arising from the marrow cells of the sternum and ribs.

Other cases related to this type of bone tumor have been reported by Jaffé[6], 1874, Sudhoff[7], 1875, Schweininger[8], 1876, and v. Lukovicz[9], 1879. In 1879, Gross[10] wrote his famous treatise on sarcoma of the long bones, based on a study of 165 cases. This has been called the most outstanding article on the subject ever written in this country. Other bone tumors, either endothelioma or closely related types, have been described by Kolaczek[11], 1880, Driessen[14], 1893, Spiegelberg[15], 1894, Volkmann[16], and Marckwald[17], 1895, Gaymard[18], and Ritter[19], 1898, Berger[20], 1900, and Sternberg[21], 1901.

In 1905, Howard and Crile[22] analyzed the nineteen cases reported by the above mentioned authors, except Gross, added four of their own, and called the tumor endothelioma, or perithelioma of bone.

Kolodny[23], in an article in which he describes a case of angio-endothelioma of bone, draws attention to the lax requirements for diagnosing endothelioma, laid down by Golgi[24] and Kolaczek[25]. He expresses the view that a careful study of the cases analyzed by Howard and Crile[22] suggests the possibility of carcinomatous metastases in some of the cases, excluding the three patients less than twenty years of age, who probably had Ewing's tumor.

FIG. 9

Roentgenogram of author's case, taken May 10, 1927. Note fungating tumor mass and definite areas of metastasis now present in the tibia.

Coley[26], 1907, discussed the diagnosis, prognosis, and treatment of bone sarcoma in general. He describes, among other cases, a round-cell sarcoma, involving the dorsal spine of a man twenty years old. The patient improved under Coley's mixed toxin treatment of erysipelas and bacillus prodigiosus, and was in perfect health at the end of five years.

In 1909 Buerger[27] presented his observations based on a study of twenty bone sarcomas, and gave his classification of bone tumors. While he did not use the word "endothelioma", some of his cases of round-cell sarcoma would be considered Ewing's tumor today.

Symmers and Vance[28], 1916, described a unique case, which they called "Multiple Primary Intravascular Hemangio-endotheliomata Associated with Symptoms of Multiple Myelomata". This case, however, could not be considered a true Ewing's tumor.

Coley[29], in 1919, recorded the results of his treatment of a large number of cases of sarcoma of the long bones, and advocated conservative treatment in such cases. In an article on sarcoma of the clavicle, Coley[30], in 1920, tabulated 109 cases collected from the literature, including his own, and discussed the end results following total excision. Some of these cases would undoubtedly be classed as Ewing's tumor today.

Bloodgood[31], in 1920, gave his classification of central primary bone tumors, based on a study of 370 cases.

In 1921 Ewing[32] reported before the New York Pathological Society a case of bone tumor occurring in a fourteen-year-old girl, which he called a diffuse endothelioma. He concluded his report with the following state-

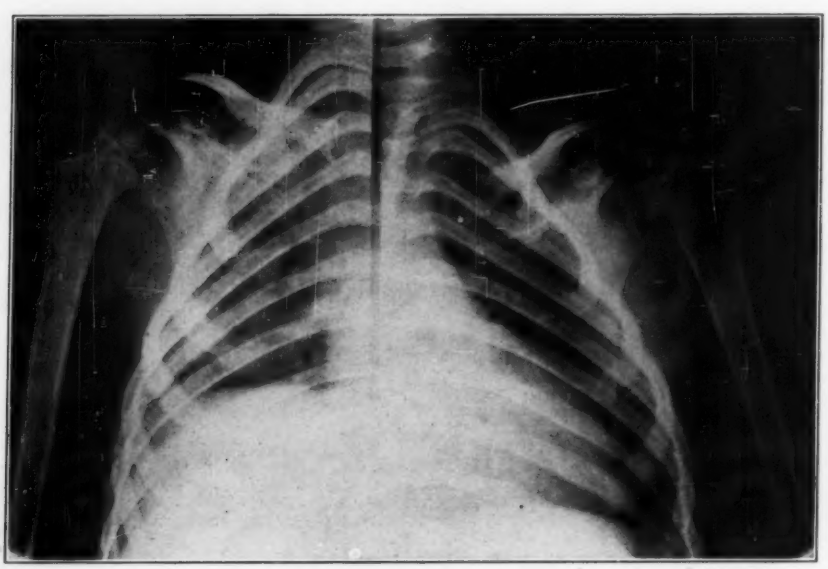

FIG. 10

Roentgenogram taken May 14, 1927. Definite metastases are seen in the lung, humerus, and scapula (right and left).

ment: "The main point of the present communication lies in the demonstration that there is a rather common tumor occurring in young subjects, commonly identified with osteogenic sarcoma, and usually called round-cell sarcoma, which is really of endothelial origin and which is marked by such peculiar gross anatomical, clinical, and therapeutic features as to constitute a specific neoplastic disease of bone".

In the same year Wells[33] discussed the relation of multiple vascular tumors of bone to myeloma, and reported a case, with autopsy, of multiple myelomatosis of bones, presenting features of angiosarcoma and multiple endothelioma of bone. The following statement by Wells is interesting: "That true hemangiomas of bone may occur, if rarely, is indicated by Trommer's[34] compilation of eight cases, including one of his own, which seem for the most part to answer to this designation. Especially well established are those cases in which typical hemangiomas were also found outside the bones."

Greenough, Simmons, and Harmer[35], 1921, gave a complete analysis of forty-three cases of bone tumors, which they classified as follows:

(1) Osteogenic sarcoma—27 cases
(2) Benign giant-cell tumors—12 cases
(3) Myeloma—3 cases
(4) Angio-endothelioma—1 case

They state that they have followed Ewing's classification in their investigation, rather than the more elaborate nomenclatures of various other writers.

Meyerding[36], in 1922, presented the results of his study of 470 cases of sarcoma of the long bones occurring in the Mayo Clinic and described the results of the treatment of 109 patients of this series, in whom microscopic diagnosis of sarcoma had been made.

With reference to results obtained from various forms of treatment, it is interesting to study the forty cases reported by Escher[37], eighty-nine by Bloodgood[38], and 250 by Coley[29].

Ewing's[39] "A Review and Classification of Bone Sarcomas", May 1922, stressed the need for a uniform nomenclature in the study of bone tumors.

In March 1920, Bloodgood[40] outlined the salient facts gathered from more than 1000 records of bone lesions; this included only those cases of tuberculous and pyogenic osteomyelitis which may resemble, clinically or roentgenologically, a periosteal or central malignant lesion.

In 1923, the excellent study of ten bone tumors by Morton and Duffy[41] appeared. These writers draw attention to the importance of the three essential points to be borne in mind in the study of bone tumor,—namely, (1) careful analysis of the clinical course, (2) correct interpretation of roentgenograms, and (3) microscopic study of the tumor tissue removed.

HISTORICAL DATA (1924–1928, INCLUSIVE)

After careful study of the literature from 1866 to 1924 relating to endothelioma of bone, one is thoroughly impressed with the lack of uni-

formity in the classification of bone tumors. This criticism applies both to clinical and to pathological reports made during this earlier period.

The author has devoted a number of months to the study of this earlier literature relating to bone tumors, with the idea of attempting to select, from the enormous number of cases reported, those which, in the light of our present knowledge, may have been Ewing's tumors. While unquestionably many tumors of the Ewing type have been included in these various earlier reports, the terminology and nomenclature employed is so overlapping and confusing, and the various classifications so numerous, that even an approximate estimation of the number of cases of this neoplasm would be far from accurate, and therefore of no particular value to the reader. Gross[10] must have met with many instances of this tumor, and as Codman[42] has so aptly said, "How valuable the original slides of his cases would be, if we had them today!"

Most of these cases have been in the past so confused with round-cell sarcomas arising in the periosteum, parosteum, and the medulla of bone, as well as with the true myelomas, that the majority of the early cases of true Ewing's tumor have necessarily been lost.

Within recent years, the American College of Surgeons saw the need of a universal classification and simplified terminology which could be used in the diagnosis of bone tumors. For the purpose of formulating such a classification, the following committee was appointed by the American College of Surgeons: Drs. James Ewing, Joseph C. Bloodgood, and Ernest A. Codman (registrar).

The classification adopted by the Bone Sarcoma Registry Committee of the American College of Surgeons is as follows:

(1) Metastatic tumors, primary in tissues other than bone.
(2) Periosteal fibrosarcoma.
(3) Osteogenic tumors.
    a. Benign.
    b. Malignant.
(4) Inflammatory conditions.
(5) Benign giant-cell tumors.
(6) Angioma.
    a. Benign.
    b. Malignant.
(7) Ewing's tumor.
(8) Myeloma.

The Registry was started in 1921. Due to the admirable work it is doing, the study of bone sarcoma is becoming more simplified, and a clear understanding is being established between clinician, radiologist, and pathologist with regard to these neoplasms.

The author has divided the consideration of the literature on endothelioma of bone into two distinct periods because of the influence of the Sarcoma Registry classification on the literature since 1923.

Considerable confusion seems to exist in the minds of certain writers as to which type of endothelial tumor of bone should be classified as Ewing's tumor. This is apparently due to an incorrect interpretation of Ewing's classification. A study of the following remarks of Kolodny[23] will serve to clarify this point: "Ewing, who has probably contributed more to the knowledge of malignant bone tumors than any other living pathologist, describes three varieties of endothelioma of bone: (1) multiple endothelioma, (2) solitary angio-endothelioma, and (3) diffuse endothelioma, known as Ewing's tumor. It is felt that the inclusion of these three groups under a common term 'endothelioma' is ill founded. An analysis of these tumors makes one wonder whether the name endothelioma is not the only feature that these groups have in common. The course, the clinical incidence, the prognosis, and the morphology are entirely different in Ewing's tumor from what they are in those grouped by Ewing under the first two headings."

The case of a primary multiple endothelioma, reported by Kolodny[43], in 1924, is an excellent illustration of a primary endothelioma of bone which is not Ewing's tumor.

Not all have accepted Ewing's tumor as differing from other tumors arising in bone to the extent that it should be given a separate classification, but such authorities as Wolbach, Mallory, Bloodgood, Smith, Coupal, and Phemister have felt that this tumor presents a distinct histological picture.

Though it was in 1921 that Ewing first described the tumor which is the subject of this communication, one must look to the literature since the year 1923 for the reports of most of the authentic cases of this neoplasm.

As far as the author has been able to determine, no effort has previously been made to enumerate the total number of these cases appearing in the literature.

Group I

This group includes only those cases, reported in the literature, which are unquestionably examples of Ewing's tumor. In each of these cases, the original report includes a description of the microscopic examination of the tissue removed, either from the parent tumor or from an area of metastasis from the tumor.

The author has been able to collect from the literature the reports of sixty-seven cases, placed here in Group I. Fifty-four of this number are found in Connor's[44] monograph. This writer has analyzed fifty-two cases classified as Ewing's tumor in the Registry of Bone Sarcoma of the American College of Surgeons, and has added two of his own.

Morton and Duffy[41], in 1923, reported a case occurring in the right femur of a boy, eight years of age. This case was associated with a pathological fracture at the junction of the middle and lower thirds of the right femur.

In their analysis of fifty cases of sarcoma of bone, 1924, MacGuire and McWhorter[45] found two cases of Ewing's tumor. One case occurred in the middle of the shaft of the femur in a man, twenty-one years of age; the other, in the upper end of the left femur of a woman, thirty years old. The microscopic diagnosis in both cases was confirmed by Dr. James Ewing.

Coley and Coley[46], in 1926 and 1927, analyzed 171 cases of tumors of long bones. Ten of these are unquestionably endothelial myeloma. Two of this number are included here in Group I (Cases 43 and 48 of Coley's and Coley's series); the remaining eight cases have been accounted for, appearing in Connor's[44] series as Cases 1, 5, 6, 7, 12, 14, 17, and 40.

Nové-Josserand and Tavernier[47], in 1927, described a case, typical of Ewing's tumor, involving the tibia in a boy, eleven years of age. They state that the lesion had its origin, two years before, in the fibula, which had been resected. A reproduction of the original roentgenogram of the fibula seems to substantiate their belief.

In his article "Endotheliomata of Bone", 1927, Pomeranz[48] described three additional cases. Though the pathologic diagnosis of Case 1 is given as "endothelial myeloma, angio-endotheliomatous type", the case seems to be a true Ewing's tumor.

Pritchard[49], in 1927, reported a case of Ewing's tumor, with autopsy, occurring in a girl of eighteen years. The right humerus was the site of the original tumor, which was diagnosed osteomyelitis. The tumor metastasized to various parts of the skeleton, including the ilium and skull.

An additional case was presented by Sycamore and Holmes[50] in 1927. The patient was a man, twenty-two years of age, with the primary tumor in the left ulna. Metastases occurred early to the lungs, and at autopsy, the bronchial glands and paravertebral and retroperitoneal tissues showed metastases. The primary tumor disappeared under roentgenotherapy, but recurred ten months later.

Witmer[51], in his thesis on endothelial myeloma, 1927, reported a case of a man, twenty-five years of age, who had a tumor of the right scapula. The scapula was excised, and the diagnosis of endothelial myeloma was made after pathological study of the specimen. No metastasis had appeared five months after the tumor had been removed, and approximately three and one-half years from the date of onset of his original symptoms.

Craver[52] reported, in 1927, a case of a tumor of the thyroid gland in a man, thirty years of age. The right arm had been amputated two years before for supposed periosteal sarcoma of the humerus, in one hospital; and in another hospital, an operation had been performed for supposed carcinoma of the thyroid. When seen in 1927, the patient was suffering from a large mediastinal tumor, said to be an extension of the carcinoma of the thyroid. By securing the microscopic sections from both hospitals where the patient had been treated previously, Craver was able to prove that the original tumor (a typical Ewing's tumor) occurred in the right humerus and metastasized later to the thyroid and mediastinal glands.

In 1928, Christian and Palmer[53] reported an unusual case of a man, aged thirty-one years, who sustained an injury to the left shin bone in 1918. He received treatment at different intervals for osteomyelitis of the left tibia; this included operations in 1919 and in 1925. At a second operation in 1925, a piece of bone was removed and diagnosed as myelosarcoma. The leg was amputated at the thigh. Metastases occurred in the lymph glands, right clavicle, skull, and cervical vertebrae. The patient was treated with Coley's toxins, and was apparently cured when last seen in January 1928. A careful study of the reported case convinces the author that it should be placed in Group I as an example of a true endothelial myeloma.

Group II

This group includes a number of cases which have either been reported as endothelial myeloma or referred to in the literature as examples of Ewing's tumor. In the author's opinion, these cases are probably endothelial myeloma but have not been included in Group I for one of the following reasons:

(1) Insufficient data accompanying the report to make a definite diagnosis of Ewing's tumor.

(2) Cases resembling so closely other types of bone tumors that all who have studied them do not agree on the diagnosis.

There are forty-one cases placed here in Group II. Because of the atypical features it presents, the author adds his case to this number, making a total of forty-two cases.

Coley and Coley[46] state: "Since Ewing's paper was written, in 1922, we have had an opportunity of studying a number of additional cases, making at present a total of twenty-six cases".

Ten of these have been accounted for under Group I. The remaining sixteen are placed in Group II because of the conflicting classifications employed at the time these cases were reported. From a study of the literature alone, it is therefore impossible to state definitely that these cases should be classified as endothelial myeloma.

The case reviewed by Coley[54], in 1928, is Case 6 of Connor's[44] series.

Faldini[55] reports that he has observed three cases showing the clinical, radiographical, and histological characters of Ewing's tumor. All were treated surgically and died during the third year after operation.

Detailed descriptions of these cases, including microscopic reports, are not contained in Faldini's article, and, for this reason, the cases are placed in Group II, though the author does not question the fact that these are true endothelial myeloma. Putti and Camurati[56] refer to the cases described by Faldini and agree that Ewing's tumor represents a distinct type of bone sarcoma.

Reuben and Peskin[57], in 1928, report two cases which, according to history, roentgenologic findings, and reaction to treatment, are Ewing

tumors. In neither case, however, has the tumor tissue been examined microscopically, and for this reason they have not been included in Group I.

For various reasons, stated in his article, Connor[44] did not include fifteen cases, classified in the Sarcoma Registry as Ewing's tumor, in his analysis. These cases are here placed in Group II.

La Presse Médicale, July 4, 1928, contains the abstract of an article by Oberling[58], entitled "*Les Réticulo-sarcomes et les Réticulo-endothéliosarcomes de la Moelle osseuse (Sarcomes d'Ewing)*". It is stated in this abstract that Oberling, personally, has observed five cases of Ewing's tumor. Unfortunately, Oberling's original article could not be obtained, and for this reason these five cases are placed in Group II of this communication.

Group III

There are three cases reported in the literature which have become confused with Ewing's tumor. While it is conceivable that all of these cases may have been endothelial myeloma, the uncertainty of their origin is so great that they cannot be classified definitely as bone tumors.

Foot[59], in 1924, recorded a case under the title of "Malignant Endothelioma". The patient was a woman, aged sixty-eight years, who, in addition to an apparent osteomyelitis of the left radius, presented a swelling in the right groin. Foot was uncertain of the site of origin of the primary growth because the left radius was not examined at autopsy. The tumor of the inguinal region was examined, and the microscopic diagnosis was "malignant endothelioma of the inguinal nodes". Metastases to the lung were reported at autopsy.

Piney[60] reported, in 1926, a case of a man, aged forty-seven years, with a "malignant endothelioma", involving the phalanx of the right middle finger and the corresponding metacarpal bone. The affected finger with its metacarpal bone was removed. It is stated in the case report that the tumor seemed to arise from the tendon sheath without involvement of the tendon itself. The tumor, in this case, may have originated in the bone, but a study of the original report reveals the fact that Piney considered it a primary malignant "reticulo-endothelioma" of the tendon sheath.

Dr. Howard Lilienthal presented before the New York Surgical Society[61] in December 1926, a girl, four years of age, upon whom he had operated for a large mediastinal tumor in April 1924. The growth could not be removed, but a piece of tissue was excised from the mass for examination. At operation, the ribs and spine were also found to be extensively involved by the tumor growth. The tissue removed from the mediastinal tumor was examined by three pathologists, who submitted the following diagnosis, respectively:

(1) Angio-sarcoma.
(2) Hemangio-endothelioma.
(3) Malignant cellular tumor of embryonal type.

The origin of this tumor was never determined.

ETIOLOGY

The etiology of Ewing's tumor is not known. It is essentially a disease of childhood, though one case occurred in a woman of sixty (Case 10 of Connor's series). Ewing[1] has observed the disease in an infant of eighteen months. About eighty per cent. of the reported cases occurred before the thirtieth year; the average age of the fifty-four cases analyzed by Connor was twenty.

Christensen[62] gives the following table in his analysis of eighty-one cases:

Years	*Male*	*Female*
1 –10	18	5
11–20	15	9
21–30	14	6
31–40	4	2
41–50	3	1
51–60	1	1
61–70	1	1
	56	25

Approximately seventy per cent. of the reported cases have occurred in male subjects.

The relationship of trauma to the etiology of this disease is questionable. In Connor's[44] series, forty per cent. of the cases gave a history of injury at the point involved, at a time near enough to the onset of the tumor to be of some significance.

Ewing[1] feels that it is difficult to reconcile the origin of the disease with trauma, and expresses the view that it appears to be much more closely connected with infection and inflammation. Among the cases analyzed by Connor[44], forty per cent. gave a history of having had signs pointing to inflammation as the cause of their trouble. Coley[54], in drawing attention to this point, said:

"This type of tumor furnishes some additional evidence in favor of the theory that malignant tumors, or at least a certain number of them, are due to some infectious cause or micro-organism. Here we have a tumor that so closely resembles osteomyelitis, or a known infectious disease, that clinical, roentgenologic, biopsical, and even microscopic examination of the tumor tissue removed, all point to a definite diagnosis of osteomyelitis; and yet, the subsequent history shows it to be a malignant tumor. If osteomyelitis is caused by a known micro-organism, is it not possible to assume that some other type of unknown micro-organism closely resembling the former, may give rise to an endothelioma type of neoplasm which so strikingly simulates osteomyelitis?"

PATHOLOGY

The typical endothelial myeloma usually occurs first in the shaft of a long bone, being more often situated near the middle of the shaft than at one of the ends of the bone. In the beginning, areas of the bone marrow are found to be cellular and opaque, due to localized and confluent collections of tumor cells. As the disease progresses, a large portion of the shaft becomes involved, the cancellous tissue is absorbed, and the shaft of the bone is honeycombed by the invading tumor cells.

The tumor is often described as an invading, expansive, bone-destroying, rather than bone-producing, neoplasm, pushing the cortex outward and finally infiltrating it.

New bone is usually produced by the periosteum in an effort to check the tumor growth, and as this protecting shell of thin bone is invaded, other similar thin shells are produced, one on the other, forming onion-like layers parallel to the shaft, thus presenting the picture so typical of this tumor. Eventually the tumor perforates the periosteum with its protecting layers of bone, and infiltrates the soft tissues, resulting in a fusiform swelling, which may perforate the overlying skin. The tumor then becomes a foul, fungous mass, resembling unhealthy granulation tissue.

The tumor is soft, due to its highly cellular composition and is generally divided into small lobules by strands of loose, coarse connective tissue. Ewing[1] has pointed out that the irregular osteolytic process of growth, together with the formation of bone by periosteum, strongly resembles osteomyelitis, but reminds us that it is far more destructive.

The tumor in its earlier stages is very frequently mistaken for osteomyelitis. Metastases may occur in the regional lymph nodes, while the skull and lungs are the most frequent seats of metastatic involvement. Any of the bones of the skeleton may become involved in the late stages of the disease. Dissemination takes place through the blood and lymph streams. Kolodny[63] states that Ewing's tumor metastasizes by way of the lymph stream more frequently than does an osteogenic sarcoma.

Ewing's tumor presents a distinct histological picture. The structure is composed of sheets of small polyhedral cells, with round, oval, or somewhat elongated nuclei. The cytoplasm is clear or stained a very delicate pink. The nuclei are small, round, or oval, and contain scattered chromaffin granules. Nucleoli are usually not distinguishable. Mitoses are numerous, but tumor giant cells are almost never seen, the cells containing only one nucleus. There is no true intercellular substance. There is occasionally a pseudo-alveolar arrangement of the cells, and in some instances the cells form capillary blood channels in which blood circulates. A perithelial arrangement of the cells is sometimes seen. Ewing[1] suggests that this relation may signify an angioblastic property.

The origin of Ewing's tumor has not been satisfactorily determined. Ewing[1] suggests that the process begins in the perivascular endothelium. He feels[64] that the cells of this tumor are "to be assigned to some endo-

thelial category, and it may be that the interpretation of 'endothelium' may have to be widened to include this group. I do not think they arise from blood or vascular endothelium. They may possibly arise from perivascular lymphatic endothelium."

Connor concludes that the cells of the reticulo-endothelial system are the point of origin and cites the suggestion made by Aschoff[65] that similar malignant tumors may arise from the reticulo-endothelial system.

For a study of the origin of blood and connective-tissue cells, the reader is referred to the works of Maximow[66], Ferrata[67], Kiyono and Takamaru[68], Aschoff[65], and Sabin[69].

After a study of the arguments advanced by writers on this subject, one is forced to agree with Kolodny[63], in concluding that the difficulties in deciding this question of origin are great, and as in other tumors, the essential experimental link in the chain of evidence is lacking.

CLINICAL COURSE

While differences of opinion exist, regarding the origin of Ewing's tumor, all agree that the history and clinical course are sufficiently characteristic to distinguish it from other tumors of bone.

The disease begins with pain in the affected region. At first, this pain is usually mild and intermittent and is frequently preceded by a history of trauma. A constitutional febrile reaction often accompanies the attack of pain, and Kolodny[63] emphasizes the point that, in the beginning, there is no increase in local temperature. As the disease progresses, local heat and other signs of inflammation appear. These attacks of pain and fever occur irregularly, but become shorter and more severe as the disease advances.

A tumor mass is usually palpable. In the beginning, the progress of the growth may be slow, having a tendency to subside or, at times, even disappear. After it reappears, it may progress rapidly in size. Ewing[1] suggests that the rapid changes in size may be due to variations in the blood supply of the vascular tissue, and to spontaneous necrosis of tumor tissue.

The diagnosis of osteomyelitis is often erroneously made, and the patient operated upon for this condition. Not infrequently the pathological report of the examination of the tissue removed confirms the clinical diagnosis.

A moderate degree of leucocytosis is usually present without striking variation from the normal ratio of the cells. In the advanced stages of the disease, leucocytosis is more pronounced, and a marked secondary anaemia is found.

Roentgenologically, the bone shows a characteristic longitudinal striation. The tumor nearly always invades half of the shaft. Radiating spicules are not often seen, but the so called onion-like layers of periosteal new bone formation are striking, which accounts for the common confusion with osteomyelitis. From a study of the roentgenograms, one receives the

impression of a disease which is invading the marrow space, separating the lamellae, and resulting in a swelling and widening of the shaft and cortex. Herendeen[70], who has devoted much study to this type of tumor, states that "the appearance of this tumor in the radiograph is so unlike most other primary bone tumors that we feel that in many instances the diagnosis can be made from the radiograph alone".

Metastases may occur in from a few months to several years, the secondary tumors appearing almost constantly in the skull and lungs. The vertebrae, long bones, pelvis, and ribs are often involved. Metastasis to the regional lymph nodes is common. Visceral metastases are apparently not frequent, though our knowledge on this point is not accurate because of the relatively few autopsies obtained in the reported cases.

The picture of the terminal stage of the disease is identical with that of other malignant tumors,—namely, emaciation and hyperpyrexia before death.

Case No. 284 of the Sarcoma Registry has frequently been cited in the literature as an illustration of the typical course of Ewing's tumor. For descriptions of this case, the reader is referred to the articles of Connor[44] and Witmer[51].

MULTIPLICITY

Considerable variation of opinion exists among the different writers as to whether the tumor is primarily single or multiple in its origin. Ewing[1] says: "That endothelial myeloma occurs as a solitary tumor is proven by the recovery of several cases, mostly adults, after treatment of the single tumor. In many cases, the course of events suggests that there may be a multiple primary origin." He further suggests that a complete examination of the entire skeleton is indicated to rule out multiple tumors in the early stages.

Connor[44] found multiple tumors present when the case was first seen in only three of his fifty-four cases. He believes that the disease begins as a single lesion and that tumors elsewhere are metastatic rather than primary.

Coley and Coley[46] believe that cases beginning with multiple primary tumors are very rare, and state that they have never observed such a case.

Kolodny[63], on the other hand, takes the opposite stand and suggests the probability that the tumors are truly multiple and not skeletal metastases.

One can only conclude that time and further study are required to clear this point.

DIAGNOSIS

In order to reduce *ad minimum* the mistakes in diagnosis, one cannot emphasize too strongly the importance of (1) a complete history and a

thorough physical examination, (2) a careful analysis of the roentgenograms, and (3) a detailed pathological study (gross and microscopic) of the tumor tissue removed.

The diagnosis must be made from chronic osteomyelitis, osteogenic sarcoma, multiple myeloma, metastatic tumors, and tuberculosis of bone.

Osteomyelitis. The diagnosis of chronic osteomyelitis should never be made before ruling out the possibility of a malignant tumor. While the two conditions can present similar pictures, a careful study of the case should lead to a correct diagnosis. Slight fever, intermittent pain, a moderate or no leucocytosis, together with the history of a gradual onset, speak more for a tumor than osteomyelitis. In the differential count of the white blood cells, the polymorphonuclears retain their normal ratio in Ewing's tumor.

In osteomyelitis, a draining sinus or a healed scar may be present. A sequestrum is not infrequently seen in the roentgenogram. There is irregular destruction of bone and a proliferative reaction in osteomyelitis. The periosteum is more apt to be elevated in osteomyelitis, while Ewing's tumor invades the periosteum without elevating it.

Microscopic examination of the tumor tissue should clear the question of diagnosis, provided a sufficient amount of tissue is removed at operation.

Finally, improvement usually takes place under radium or roentgen-ray treatment in endothelial myeloma.

Osteogenic Sarcoma. Osteogenic sarcoma attacks the end rather than the shaft of the bone. It is a bone-forming neoplasm, whereas Ewing's tumor characteristically destroys bone. The new bone formed in osteogenic sarcoma is deposited at a right angle to the shaft, giving the appearance of radiating spicules in the roentgenogram; usually less than half of the bone is involved. Osteogenic sarcoma metastasizes to regional lymph glands and to bone much less frequently than does endothelial myeloma.

The following table given by Sycamore and Holmes[50], modified by Connor, presents a splendid summary of the differential diagnosis in these two conditions:

DIFFERENTIAL DIAGNOSIS OF ENDOTHELIAL MYELOMA

(Modified by Connor)

	Endothelial Myeloma	*Osteogenic Sarcoma*
1.	Central part of shaft.	End of the shaft.
2.	Osteolytic.	Osteoblastic.
3.	Widens shaft.	Does not widen shaft, may narrow it.
4.	Destroys cortex in vertical, linear manner.	Destroys cortex little, and then from side to side.
5.	Involves more than half of shaft.	Involves less than half of shaft.
6.	New bone, if any, parallel to shaft.	New bone radiating from surface of shaft.
7.	Multiple in bones.	Rarely multiple in bones.

When *metastatic tumors* of bone occur, the primary growth can usually be found elsewhere. As a rule, a small area of bone is involved by the metastatic process; the bony contour is seldom destroyed, and the soft tissues rarely invaded. Metastatic tumors occur in the extremities of life. Carcinoma is the important growth, producing metastases to bone during middle age and after. Hirsch and Ryerson[71] feel that many of the so called primary tumors of bone are really metastases from a primary carcinoma of the lung, the original tumor having been overlooked. In the first decade of life, tumors resulting from cell rests, inclusions, or displacements may be found anywhere in the body. As Connor[44] points out, these occasionally metastasize to or even arise in bone, the most frequent metastases probably being from neuroblastomas from the suprarenal glands and the sympathetic ganglia.

Multiple myeloma usually occurs after the age of thirty, and an important feature of this disease is the finding of Bence-Jones protein in the urine. Walters[72] concludes from his studies that "Bence-Jones proteinuria is significant from a diagnostic and from a prognostic standpoint of multiple myeloma, since it occurs in eighty per cent. of all cases and usually is followed by death within two years". This disease produces sharply defined areas of bone destruction. It forms multiple nodules in the same bones and is more frequently found in other bones from the beginning than is the case with endothelial myeloma. Multiple myeloma tends to limit itself to the bone marrow but metastasizes to other organs of the body more frequently than does Ewing's tumor.

Tuberculosis of Bone. A typical case of endothelial myeloma should not be confused with the usual case of tuberculosis of bone. While it is true that both conditions occur in young subjects, and in each a history of local antecedent trauma is frequently given, the two diseases present points of difference which are striking enough to differentiate them.

Endothelial myeloma, as a rule, occurs in young subjects who present evidence of being in good health, whereas tuberculosis of bones is more frequently found in persons whose general condition is below par. Endothelial myeloma begins very rarely in the epiphysis of the bone, while tuberculosis nearly always begins in the epiphysis and involves the joint in the comparatively early stages of the disease.

The roentgenogram shows atrophy of bone in tuberculosis; in endothelial myeloma, the bone is widened, producing a heavy dense appearance as in osteomyelitis. Pain is a symptom common to both diseases, but in endothelial myeloma, it is usually more severe and in the early stages occurs in attacks accompanied by fever. An evening rise of temperature is more often noted in tuberculosis.

The duration of the disease is usually longer and its progress slower in tuberculosis. Ewing's tumor responds favorably, at least temporarily, to radium and roentgen-ray therapy.

In rare instances, when Ewing's tumor begins in the epiphysis of a long bone and infiltrates the soft tissues early, as in the author's case, the two conditions may present pictures so similar that the correct diagnosis may be missed entirely.

PROGNOSIS AND TREATMENT

While it is recognized that prognosis as to life expectancy in Ewing's tumor cannot be given, a study of the reported cases reveals certain definite and important facts. Such facts, relating to prognosis in any disease, can only become established through the study of a large series of cases presenting the disease in question.

The largest collection of authentic cases of Ewing's tumor is found in the Sarcoma Registry. Consequently, one must look to the reports of the various writers who have studied these cases, in order to obtain the most valuable facts and figures regarding the prognosis and treatment of Ewing's tumor.

Connor[44] points out that in twenty-four patients who died of this disease, the average duration of life from the onset was nineteen months. In the fifty-four cases, both dead and alive, the average duration was over three years. Fifteen of the fifty-four cases had survived more than four years after the onset of the disease. This writer also draws attention to the fact that the prognosis is distinctly better in Ewing's tumor than in osteogenic sarcoma.

Kolodny[63] states: "The wide range of life duration is evidenced by the fact that one patient of the Registry cases is alive sixteen years after the onset of the disease, while several patients died five months after the onset of the tumor".

The author is indebted to Dr. W. B. Coley* for recent valuable information on this subject. He states that of his cases two patients are living twenty-one years later. In both cases, the clavicle was the seat of the tumor, and both were treated with toxins following excision.

All agree that the treatment has the greatest influence on the prognosis in endothelial myeloma.

When the diagnosis of endothelial myeloma is suspected, Ewing[1] believes that the first indication is treatment by radiation in full doses and over considerable periods. The rapid response to radiation of endothelial myeloma also differentiates this tumor from osteogenic sarcoma.

Connor[44] concludes that radium is the first thought in treatment, with the roentgen-ray a close second. Only one patient of his series had been treated with radium alone, without any surgery, and that patient was living four years later.

Recurrence of the tumor generally takes place, unfortunately, after it has temporarily disappeared or regressed under radiation. The question of how to best treat the cases after recurrence is difficult to answer.

*Personal communication.

Ewing[1] suggests that the safest method would seem to call for amputation or local excision to prevent recurrence. He feels that until a larger series of five-year cures from radiation is secured with inaccessible tumors, operative measures cannot safely be dispensed with.

In young children, secondary tumors occur so uniformly and so early after amputation that little is to be gained by amputation. The older the patient, the better the prognosis from amputation.

Coley's toxin has unquestionably been of great value in some cases; but in the majority of cases receiving toxins, radium, roentgen-ray therapy, or radical surgery has also been employed. It is obviously impossible to estimate the relative values of two or more therapeutic agents employed simultaneously in the same case.

Connor's[44] concluding and pleasing paragraph on this subject includes the principal points of our present knowledge of the therapy and prognosis of Ewing's tumor. He concludes: "Finally it is urged that endothelial myeloma should not be looked on as hopelessly fatal from the start; rather, that here is a tumor that presents the opportunity to use radium, the roentgen-ray, and intelligent surgical judgment when they are likely to be attended with considerable success; and that a consistent and persistent attack on a terrible disease will frequently control it temporarily, and, it is believed, in a gratifying number of cases, permanently".

SUMMARY

There are recorded in the literature one hundred and eight cases of Ewing's tumor (endothelial myeloma). To this number, the author adds an atypical case, which has been accepted as an endothelial myeloma by those who have studied it.

These cases are here divided into two separate groups. Group I includes only those concerning which there can be no question as to the correct diagnosis of Ewing's tumor. There are a total of sixty-seven cases in this group. Group II includes forty-two cases which, for various reasons previously stated, are not placed in Group I. These are here classified as probable cases of Ewing's tumor. The case reported in this communication is included among this number because of the atypical features which it presents. While the typical Ewing's tumor presents a characteristic clinical, radiographic, and histological picture, atypical cases are met with occasionally.

In rare instances, when Ewing's tumor begins in the epiphysis of a long bone, it may be difficult to differentiate the condition from tuberculosis of bone.

BIBLIOGRAPHY

1. Ewing, J.: Endothelioma. In Neoplastic Diseases. Ed. 3. Philadelphia, W. B. Saunders Co., p. 328, 1928.
2. Lücke, A.: Beiträge zur Geschwulstlehre. Virchow's Arch. f. path. Anat., XXXV, 524, 1866.

3. KOCHER, T.: Zur Kenntniss der pulsirenden Knochengeschwülste nebst Bemerkungen über hyaline Degeneration (resp. Cylindroma). Virchow's Arch. f. path. Anat., XLIV, 311, 1868.
4. BILLROTH: Quoted by Hildebrand: Deutsche Ztschr. f. Chir., XXXI, 271, 1890.
5. ENGELMANN: Quoted by Howard and Crile. Ann. Surg., XLII, 359, 1905.
6. JAFFÉ, T.: Zur Kenntniss der gefässreichen Sarcome. Langenbeck's Arch. f. klin. Chir., XVII, 91, 1874.
7. SUDHOF: Quoted by Hildebrand: Deutsche Ztschr. f. Chir., XXXI, 275, 1890.
8. SCHWEININGER: Quoted by Howard and Crile. Ann. Surg., XLII, 360, 1905.
9. v. LUKOVICZ: Quoted by Howard and Crile. Ann. Surg. XLII, 360, 1905.
10. GROSS, S. W.: Sarcoma of the Long Bones; Based upon a Study of 165 Cases. Am. J. Med. Sciences, LXXVIII, 338, 1879.
11. KOLACZEK: Quoted by Howard and Crile. Ann. Surg., XLII, 361, 1905.
12. ZAHN: Quoted by Howard and Crile. Ann. Surg., XLII, 361, 1905.
13. HILDEBRAND: Über das tubuläre Angiosarkom oder Endotheliom des Knochens. Deutsche Ztschr. f. Chir., XXXI, 263, 1890.
14. DRIESSEN: Quoted by Howard and Crile. Ann. Surg., XLII, 361, 1905.
15. SPIEGELBERG: Quoted by Howard and Crile. Ann. Surg., XLII, 362, 1905.
16. VOLKMANN, R.: Über endotheliale Geschwülste, zugleich ein Beitrag zu den Speicheldrüsen- und Gaumentumoren. Deutsche Ztschr. f. Chir., XLI, 1, 1895.
17. MARCKWALD: Ein Fall von multiplem, intravasculärem Endotheliom in den gesammten Knochen des Skelets (Myelom, Angiosarcom). Virchow's Arch. f. path. Anat., CXLI, 128, 1895.
Also (Abstract) Centralbl. f. allg. Path. u. path. Anat., V, 859, 1894.
18. GAYMARD: Quoted by Howard and Crile. Ann. Surg., XLII, 363, 1905.
19. RITTER: Quoted by Howard and Crile. Ann. Surg., XLII, 363, 1905.
20. BERGER, P.: Les Endothéliomes des Os. Rev. de Chir., XXI, 1, 1900.
21. STERNBERG, C.: Ein Fall von multiplem Endotheliom ("Krukenberg'schem Tumor") des Knochenmarks. Centralbl. f. allg. Path. u. path. Anat., XII, 625, 1901.
22. HOWARD, W. T., AND CRILE, G. W.: A Contribution to the Knowledge of Endothelioma and Perithelioma of Bone. Ann. Surg., XLII, 358, 1905.
23. KOLODNY, A.: Angio-endothelioma of Bone. Arch. Surg., XII, 854, 1926.
24. GOLGI, CAMILLO.: Sulla Struttura e sullo Svillappe degli Psammomi. Pavia, 1869.
25. KOLACZEK, J.: Über das Angio-Sarkom. Deutsche Ztschr. f. Chir., IX, 1, 1878.
26. COLEY, W. B.: Bone Sarcoma: Diagnosis, Prognosis, and Treatment. Surg., Gynec., Obstet., VI, 129, 1908.
27. BUERGER, L.: Bone Sarcoma. Observations on Twenty Bone Sarcomata. Surg., Gynec., Obstet., IX, 431, 1909.
28. SYMMERS, D., AND VANCE, M.: Multiple Primary Intravascular Hemangio-Endotheliomata of the Osseous System Associated with the Symptoms of Multiple Myelomata—A Lesion Hitherto Undescribed. Am. J. Med. Sciences, CLII, 28, 1916.
29. COLEY, W. B.: Further Observations on the Conservative Treatment of Sarcoma of the Long Bones. Ann. Surg., LXX, 633, 1919.
Also Trans. Am. Surg. Assn., XXXVII, 273, 1919.
30. COLEY, W. B.: Sarcoma of the Clavicle—End Results Following Total Excision. Ann. Surg., LXXII, 231, 1920.
31. BLOODGOOD, J. C.: Bone Tumors, Benign and Malignant. A Brief Summary of the Salient Features, Based on a Study of Some 370 Cases. Am. J. Surg., XXXIV, 229, 1920.
32. EWING, J.: Diffuse Endothelioma of Bone. Proc. New York Path. Soc., XXI, 17, 1921.
33. WELLS, H. G.: The Relation of Multiple Vascular Tumors of Bone to Myeloma. Arch. Surg., II, 435, 1921.

34. Trommer, B.: Zur Lehre der Hämangiome der Wirbelsäule. Frankfurter Ztschr. f. Path., XXII, 313, 1919–1920.
35. Greenough, R. B., Simmons, C. C., and Harmer, T. W.: Bone Sarcoma. An Analysis of the Cases Admitted to the Massachusetts General and Collis P. Huntington Memorial Hospitals from Jan. 1, 1911 to Jan. 1, 1921. J. Orthop. Surg., III, 602, Nov. 1921.
36. Meyerding, H. W.: Sarcoma of the Long Bones. A Study of Microscopically Proved Cases. Surg., Gynec., Obstet., XXXIV, 321, 1922.
37. Escher, A.: Über die Sarkome der Extremitätenknochen. Arch. f. klin Chir., CXIV, 545, 1920.
38. Bloodgood, J. C.: The Diagnosis and Treatment of Bone Lesions: A Brief Summary of the Salient Features. Am. J. Roentgenol., X, 42, 1923.
39. Ewing, J.: A Review and Classification of Bone Sarcomas. Arch. Surg., IV, 485, 1922.
40. Bloodgood, J. C.: The Diagnosis and Treatment of Benign and Malignant Tumors of Bone. J. Radiol., I, 147, Mar. 1920.
41. Morton, J. J., and Duffy, W. C.: A Clinical and Pathological Study of Ten Bone Tumors. Arch. Surg., VII, 469, 1923.
42. Codman, E. A.: Bone Sarcoma. An Interpretation of the Nomenclature Used by the Committee on the Registry of Bone Sarcoma of the American College of Surgeons. New York, Paul B. Hoeber, 1925.
43. Kolodny, A.: A Case of Primary Multiple Endothelioma of Bone. With Special Emphasis on Its Roentgenologic Features. Arch. Surg., IX, 636, 1924.
44. Connor, C. L.: Endothelial Myeloma, Ewing. Report of Fifty-four Cases. Arch. Surg., XII, 789, 1926.
45. MacGuire, C. J., and McWhorter, J. E.: Sarcoma of Bone. An Analysis of Fifty Cases. Arch. Surg., IX, 545, 1924.
46. Coley, W. B., and Coley, B. L.: Primary Malignant Tumors of the Long Bones. Arch. Surg., XIII, 779, 1926.
Also Arch. Surg., XIV, 63, 1927.
47. Nové-Josserand and Tavernier: Tumeurs Malignes des Os. Paris, Doin & Cie, 1927.
48. Pomeranz, M. M.: Endotheliomata of Bone. Report of Three Case. J. Bone and Joint Surg., IX, 524, July 1927.
49. Pritchard, J. E.: Ewing's Sarcoma. A Report of a Case. Canadian Med. Assn. J., XVII, 1164, 1927.
50. Sycamore, L. K., and Holmes, G. W.: Endothelial Myeloma (Ewing's tumor). Am. J. Roentgenol., XVIII, 223, 1927.
51. Witmer, J. D.: Endothelial Myeloma; Case Report and Discussion on Bone Sarcoma with Emphasis on Endothelial Myeloma. Long Island Med. J., XXI, 619, 1927.
52. Craver, L. F.: Metastasis to Thyroid Gland from Endothelial Myeloma of Bone; Rapid Regression Resulting from Roentgen-ray Treatment. J. Lab. and Clin. Med., XII, 878, 1927.
53. Christian, S. L., and Palmer, L. A.: An Apparent Recovery from Multiple Sarcoma. Am. J. Surg., IV, 188, 1928.
54. Coley, W. B.: The Differential Diagnosis of Sarcoma of the Long Bones. J. Bone and Joint Surg., X, 420, July 1928.
55. Faldini, G.: È il Tumore di Ewing una Entità Morbosa? Arch. Ital. di Chir., XIX, 851, 1927–1928.
56. Putti, V., e Camurati, M.: Trattamento dei Tumori ossei. Arch. Italiano di Chir., XIX, 842, 1928.
Also Clin. Chir., IV, 42, 1928.
57. Reuben, M. S., and Peskin, A. R.: Ewing's Endothelioma. Arch. Pediat., XLV, 116, 1928.

58. OBERLING, C.: Les Réticulo-sarcomes et les Réticulo-endothéliosarcomes de la Moelle osseuse (Sarcomes d'Ewing). Bull. de l'Assoc. franc. p. l'Etude du Cancer, XVII, 259, 1928.
59. FOOT, N. C.: Report of a Case of Malignant Endothelioma with Necropsy. J. Med. Research, XLIV, 417, 1924.
60. PINEY, A.: Endotheliomas: with Special Reference to Those Growing in a Compact Form. Arch. Path. and Lab. Med., II, 301, 1926.
61. LILIENTHAL, H.: Transactions, New York Surgical Society. Mediastinal Sarcoma. —Treated by Coley's Fluid. Ann. Surg., LXXXV, 615, 1927.
62. CHRISTENSEN, F. C.: Bone Tumors. Ann. Surg., LXXXI, 1074, 1925.
63. KOLODNY, A.: Bone Sarcoma—The Primary Malignant Tumors of Bone and the Giant-cell Tumor. Surg., Gynec., Obstet., XLIV, Pt. II, Apr. 1927.
64. EWING, J.: Further Report on Endothelial Myeloma of Bone. Proc. New York Path. Soc., XXIV, 93, 1924.
65. ASCHOFF, L.: Lectures on Pathology. New York, Paul G. Hoeber, 1924.
66. MAXIMOW, A. A.: Relation of Blood Cells to Connective Tissues and Endothelium. Physiolog. Rev., IV, 533, Oct. 1924.
67. FERRATA, A.: Le Emopatie. Milano, 1918. Quoted from Maximow.
68. KIYONO, K. AND TAKAMARU, NAKANOIN: Weitere Untersuchungen über die histiozytären Zellen. Acta Scholae Med. Univ. Imper. Kioto, III, 55, 1919. Quoted by Aschoff.
69. SABIN, F. R.: On the Origin of the Cells of the Blood. Physiolog. Rev., II, 38, Jan. 1922.
70. HERENDEEN, R. E.: Diagnosis and Results in the Radiation Treatment of Some Medullary Bone Tumors. Radiology, VII, 140, 1926.
71. HIRSCH, E. F., AND RYERSON, E. W.: Metastases of the Bone in Primary Carcinoma of the Lung. A Review of So-called Endotheliomas of the Bones. Arch. Surg., XVI, 1, 1928.
72. WALTERS, W.: Chronic Nephritis with Bence-Jones Proteinuria (Abstract). J. Am. Med. Assn., LXXVII, 1843, 1921.
73. JOLL, C. A.: Metastatic Tumors of Bone. British J. Surg., XI, 38, 1923.
74. RIBBERT, HUGO: Über das Myelom. Centralbl. f. allg. Path. u. path. Anat., XV, 337, 1904.
75. WALLGREN, A.: Über die Natur der Myelomzellen. Virchow's Arch. f. path. Anat., CCXXXII, 381, 1921.
76. BAETJER, F. H.: Differential Diagnosis of Bone Tumors. Am. J. Roentgenol., V, 260, 1918.
77. MEYERDING, H. W.: The Value of the Roentgen Ray in the Diagnosis and Prognosis of Sarcoma of the Long Bones. J. Bone and Joint Surg., V, 323, Apr. 1923.
78. NICHOLS, B. H.: Roentgen Diagnosis of the More Important Tumors of the Long Bones. Surg. Gynec. Obstet., XXXV, 301, 1922.
79. BLOODGOOD, J. C.: The Differential Diagnosis of Periosteal Bone Lesions. Radiology, III, 432, 1924.
80. MALLORY, F. B.: The Histological Classification of Tumors. Boston Med. and Surg. J., CLXI, 137, 1909.
81. MALL, F.: The Vessels and Walls of the Dog's Stomach. Johns Hopkins Hosp., Rep. I, 1, 1896. Quoted by Piney.
82. CORNER, G. W.: Contributions to Embryology. Carnegie Inst. Washington, IX, 85, 1920. Quoted by Piney.
83. GESCHICKTER, C. F., AND COPELAND, M. M.: Multiple Myeloma. Arch. Surg., XVI, 807, 1928.

AN UNUSUAL CONGENITAL DEFORMITY OF THE HAND COMBINED WITH SUPERNUMERARY TOES

A Case Report*

BY MORRIS B. COOPERMAN, M.D., PHILADELPHIA, PA.

Supernumerary toes and fingers are not uncommon, having a hereditary basis in a great majority of cases which may be traced through several generations. They frequently exist both on the hand and foot. Generally they are marginal, less often central. There is seldom any great difficulty, with the aid of the x-ray, in deciding which digits are superfluous. It sometimes happens that the supernumerary digit and its metacarpal or metatarsal is more or less perfect and closely united with another. This condition is seen more often in the thumb.

The following case is concerned with a rare malformation of the hand caused by fusion of a supernumerary metacarpal to the lateral ulnar margin of the fifth metacarpal. This deformity was unsightly and interfered with the normal function of the hand. The patient also presented a supernumerary sixth toe on each foot. The favorable results following operation prompted a report of this case.

CASE REPORT

H. H., age nineteen, female, was first seen by the writer on March 4, 1930. She presented supernumerary toes on both feet and an osseous deformity of the left hand existing since birth. When four months of age, the sixth finger was removed from the left hand by the family physician, but apparently the metacarpal remained. As she grew older, a bony prominence was observed, projecting from the outer border of the hand.

A brother has a supernumerary toe on each foot. He had a sixth finger on each hand which was removed immediately after birth.

Her previous medical history is irrelevant. Aside from a low-grade mentality and a chronic sinusitis, this patient is normal.

The hand revealed a projection, angular in character, extending in an ulnar direction, with the skin creased over the apex. The metacarpophalangeal joint had a restricted range of motion, the distal phalanx curving radially. The feet presented six toes, the sixth toe on each foot overlapping the fifth.

An x-ray examination of the left hand revealed a rather striking deformity of the fifth metacarpal. There was a distinct bony outgrowth from the ulnar aspect of the fifth metacarpal which was an integral part of the bone. The medullary canal and the cortex of the outgrowth were continuous with the metacarpal. The base was broad, while the head was of normal size and was in close contact with the head of the adjacent metacarpal. The interosseous space between the fourth and fifth metacarpals was wide because of the increased outward convexity of the malformed metacarpal.

X-ray examination of the feet showed the following: *Right*—From the internal aspect of the base of the proximal phalanx of the fifth toe was seen a bony outgrowth similar to that described in the hand. A small and what was apparently a distinct phalanx of the supernumerary toe articulated with this exostosis. *Left*—The condition here was somewhat different. There was an entire supernumerary toe consisting of three phalanges, the normal fifth toe and the supernumerary toe both articulated with the fifth metatarsal.

*Presented before the Medical League Association, Philadelphia, Pa., May 26, 1930.

FIG. 1

Supernumerary metacarpal before operation.

FIG. 2

Result after operation.

The patient was admitted to the hospital on March 5, 1930, for operation. Wassermann was negative; urine and blood showed nothing abnormal.

Operation was performed the next day under nitrous-oxid anaesthesia. An incision, three inches long, was made over the ulnar aspect of the left hand; the soft tissues were dissected away from the bony outgrowth, bringing it clearly into view. A narrow periosteal flap with the base at the proximal end of the fifth metacarpal was dissected clear from the bone and retracted upward. The deformity consisted of a hard flattened plate of bone which extended outward for about an inch from the interosseous border of the fifth metacarpal. The angular projection was chiseled away flush with a line drawn from the base of the fifth metacarpal to the head. Considerable difficulty was encountered in removing this osseous deformity because of its ivory-like hardness. The edge of the bone was then filed smooth and the flap of periosteum was sutured over it with No. 0 catgut. Hemorrhage was slight and controlled by ligature. Interrupted sutures of No. 1 chromic catgut were used to unite the overlying muscle. The redundant skin was left intact and sutured by dermal sutures. Sterile dressing and splint were applied to the hand.

The fifth and sixth toes of each foot were disarticulated by the racket incision. The reasons for removing both the fifth and sixth toes were the extreme width of the foot and the fact that if only one toe was removed there would have still remained a malformation which would have given rise to trouble later on.

The postoperative course was uneventful. The sutures were removed on the ninth day and the patient discharged March 18, 1930, in good condition. X-ray examination of the hand after operation revealed complete removal of the supernumerary metacarpal.

The results obtained in this case both from a functional and cosmetic standpoint are highly satisfactory.

BILATERAL (NINETY DEGREES) ROTATORY DISLOCATION OF THE ATLAS UPON THE AXIS

BY PAUL W. GREELEY, M.D., WINNETKA, ILLINOIS

In searching the literature on luxations of the atlas, it was surprising to find how frequently rotatory dislocations of the atlas upon the axis have occurred. Usually, however, the dislocation is unilateral or the so called "rotatory dislocation of the atlas".

Owing to the unusual anatomical differences that occur between the two first cervical vertebrae, as compared with the relations existing else-

FIG. 1

Anterior-posterior view before reduction.

FIG. 2

Lateral view before reduction showing mandible over left shoulder and at right angles to the cervical spine.

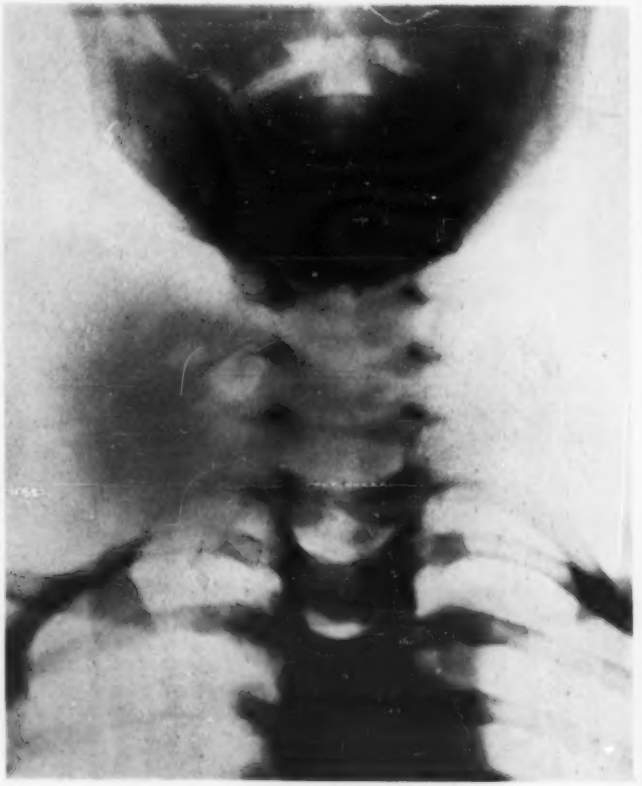

FIG. 3

Anterior-posterior view after reduction.

FIG. 4

Lateral view after reduction.

where along the spinal column, one can more readily understand why such dislocations may take place. The combination of the flat articular surfaces and the laxness of the ligaments and supporting muscles of the neck tends to a wide degree of rotation. During times of unconsciousness, whether due to anaesthesia, head injuries, or other causes, it is readily conceivable that these ligaments and muscles would permit some dislocation to take place if some outside force is exerted. Usually dislocations of the atlas upon the axis are caused by falls or blows upon the head, or by extreme turning of the head by an anaesthetist.

The usual cases reported are those of the simple rotatory type,—*i.e.*, where one side of the atlas is dislocated anteriorly, while the other side remains intact. The odontoid process may be, but is not usually, fractured in this type of injury. In the more extreme cases there is also some tearing of the ligamentous structures, especially those attaching themselves to the odontoid process. Usually there is little involvement of any great nerve centers, although it must be remembered that the medulla lies directly below the atlas and axis, and any extreme movement could readily cause respiratory difficulties, even sudden death. Sometimes one finds a localized pharyngeal anaesthesia, dysphagia, persistent neuralgia, and inability to properly open the mouth.

A very unusual type of case (the one presented here) is the double rotatory dislocation of the atlas. In this type the atlas is dislocated anteriorly on one side and posteriorly on the other side (Fig. 1). The odontoid process is more apt to be fractured in this variety and ligamentous tearing is quite probable. The medulla must be rotated somewhat and sudden death is likely to occur. The amount of rotation can be as much as ninety degrees. Pain is not always present.

The case of the writer is of a boy, five years of age, who had been struck by an automobile truck. When first seen the most striking feature was that the patient's head was rotated to an angle of ninety degrees to the rest of his body, so that his chin was above his left shoulder (Fig. 2). He was able to move his head,

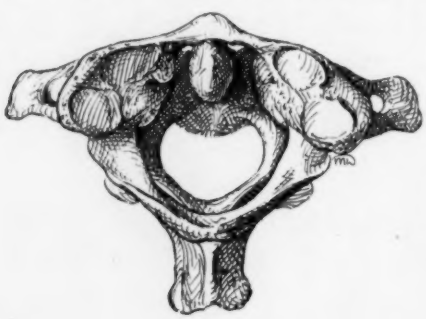

FIG. 5

Artist's drawing showing normal relations between atlas and axis as seen from above.

FIG. 6

Artist's drawing showing probable relations of atlas and axis in this case.

or have it moved, about ten degrees in either direction from this point. Further motion brought immediate pain and muscle spasm in the neck. While lying quietly there was no pain. He could only partially open his mouth.

X-ray examination (Figs. 1 and 2) showed the atlas dislocated upon the axis to an angle of ninety degrees. Satisfactory pictures of the odontoid process could not be obtained due to the patient's inability to open his mouth sufficiently. However, Figure 2 will show the general relation of the mandible to the cervical spine. The x-ray examination also revealed a linear fracture of the right temporal bone and a transverse fracture of the second and third metatarsals of the right foot.

The patient's family was first warned of his potential predicament, after which a reduction of the dislocation was attempted. Under light ether anaesthesia the patient's head was grasped under the mandible and under the occiput and gentle traction applied. An assistant applied countertraction on the shoulders. Under this traction the head was rotated towards the center, at which time the operator could feel the atlas slip back into its normal position over the axis. No respiratory difficulties occurred! The patient soon awakened and could turn his head normally again. To insure against the possibility of a redislocation, the patient was kept in bed on his back for three weeks following, with his head between two sand bags. Since the reduction he has experienced no pain and is apparently as normal as before his accident.

SUMMARY

1. Uncomplicated simple rotatory dislocation of the atlas occurs comparatively commonly.

2. Bilateral rotatory dislocation is very uncommon and is quite apt to be accompanied by sudden death.

3. A case of bilateral rotatory dislocation with recovery is reported in this paper.

BIBLIOGRAPHY

1. Uhde, Hagermann und Boettger: Luxatio antlantis violenta. Arch. f. klin. Chir., XXII, 217, 1878.
2. Ogilvy, C.: Subluxations of the Atlas upon the Axis. Am. J. Orthop. Surg., XII, 314, Oct. 1914.
3. Blaine, E. S.: Manipulative (chiropractic) Dislocations of the Atlas. J. Am. Med. Assn., LXXXV, 1356, 1925.
4. Naegeli, Th.: Atlasluxation nach vorn mit Fraktur des Zahnfortsatzes des Epistropheus. Spätlähmung und Ausgang in Heilung. Deutsche Ztschr. f. Chir., CXLVIII, 269, 1919.
5. Mixter, S. J. and Osgood, R. B.: Traumatic Lesions of the Atlas and Axis. Ann. Surg., LI, 193, 1910.
6. Corner, E. M.: Rotary Dislocations of the Atlas. Ann. Surg., XLV, 9, 1907.
7. Jacobs, C. M.: Atlas and Axis Luxation. Am. J. Orthop. Surg., XVI, 357, Oct. 1918.
8. Ruszynski, F.: Beitrag zur Therapie der Luxationen und Luxationsfrakturen im unteren Kopfgelenk. Deutsche Ztschr. f. Chir., CXCVIII, 76, 1926.
9. Brinkmann, E.: Die Drehungsverrenkung des Atlas. Klin. Wchnschr., VII, 649, 1928.
10. Hayek, H.: Untersuchungen über Epistropheus, Atlas und Hinterhauptsbein. Morphol. Jahrb., LVIII, 269, 1927.
11. Königswiese, A.: Über die Beugungsluxation der Atlas durch Muskelzug und deren Mechanismus. Ztschr. f. Orthop. Chir., XLIX, 207, 1927–1928.
12. D'Amato, G.: Sulla Torso-lussazione con Uncinamento dell'Atlante sull'Epistrofeo. Radiol. Med., XIV, 120, 1927.

13. Tescola, C.: Lussazione Bilaterale dell'Atlante con Frattura del Dente dell'Epistrofeo senza Sintomi Midollari. Arch. Ital. di Chir., IX, 454, 1924.
14. Sudeck, P.: Über die Drehungsverrenkung des Atlas. Deutsche Ztschr. f. Chir., CLXXXIII, 289, 1923–1924.
15. Forbes, R. D.: Dislocations and Fractures of the Atlas. Northwest. Med., XX, 274, 1921.
16. Swanberg, H.: Anterior Dislocation of Atlas Following Tonsillectomy. J. Am. Med. Assn., LXXII, 107, 1919.
17. Oliver, P.: Forward Dislocation of Atlas on Axis. Surg. Clinics of Chicago, III, 1185, 1919.
18. Spalteholz, W.: Hand Atlas of Human Anatomy. Ed. 3, Philadelphia, J. B. Lippincott & Co., Vol. I, pp. 74, 76, and 182,1923.

News Notes

Just as *The Journal* goes to press, word has been received of the death of Dr. C. N. Callander of Fargo, North Dakota, who died on July 31 at San Francisco, California. For several years Dr. Callander has served as a member of the Advisory Editorial Staff of *The Journal*.

Dr. A. Bruce Gill has recently moved his office to 2001 Aldine Building, 1930 Chestnut Street, Philadelphia, Pennsylvania.

Dr. H. Winnett Orr and Dr. James E. M. Thomson announce the association with them of Dr. Fritz Teal. Their office is located at 1023 Sharp Building, Lincoln, Nebraska.

Dr. Albert Edward Flagstad has announced the opening of an office at 1549 Medical Arts Building, Minneapolis, Minnesota.

Dr. Prescott LeBreton, formerly of Buffalo, New York, has moved to St. Petersburg, Florida. His office will be in the American Legion Hospital for Crippled Children.

The Editor of *The Journal* was recently honored by his election as Corresponding Member of the Deutsche Orthopädischen Gesellschaft.

With this issue *The Journal* is glad to announce the appointment of Dr. Bedřich Frejka of Brno as Foreign Editor for Czecho-Slovakia. At the Annual Meeting of the Czecho-Slovakian Orthopaedic Society held in June, Dr. Frejka was elected President of that organization.

Mr. R. Watson Jones, M. Ch. Orth., F.R.C.S., has been appointed the representative of the British Orthopaedic Association on the Advisory Editorial Staff of *The Journal*.

Two other foreign representatives have been added to the Advisory Editorial Staff of *The Journal:* Dr. Eugene Hallauer, Zürich, Switzerland; and Dr. Max Böhm, Berlin, Germany.

The Congress of **The International Society of Orthopaedic Surgery** is to be held in Paris on October 2, 3 and 4. A report of this meeting will appear in the next issue of *The Journal*.

The Annual Roll Call of **The American Red Cross** is held this year from Armistice Day to Thanksgiving Day, November 11 to 27. The important work of this organization is supported largely through the membership dues received during this roll call. The increasing demand for Red Cross service calls for corresponding increase in membership this year.

The International Assembly of the **Interstate Postgraduate Medical Association of North America** will be held at the Municipal Auditorium, Minneapolis, Minnesota, October 20 to 24. Detailed information about the Assembly may be obtained from the Executive Secretary, Dr. Edwin Henes, Jr., 445 Milwaukee Street, Milwaukee, Wisconsin.

At the Executive Committee Meeting of the **British Orthopaedic Association** held on June 29, the following were elected Associate Members:

M. G. Kini, 1 Kennet Lane, Egmore, Madras, India.

H. L. C. Wood, F.R.C.S., King's College Hospital, London, S.E. 5.

A. L. Moreton, F.R.C.S., Alexandra Hospital, Swanley, Kent.

The following were elected Full Members:

H. F. McAuley, 51, Fitzwilliam Square, Dublin.

E. A. Lindsay, 146 Harley Street, London, W. 1.

The Forty-fourth Annual Meeting of the American Orthopaedic Association was held in Boston, under the presidency of Dr. Z. B. Adams, on June 18, 19, 20, and 21.

The Committee arranged an excellent program. June 18 was a Clinical Day, devoted to visits to the Massachusetts General, Children's, City, Robert Brigham, and Carney Hospitals. At each place demonstrations had been arranged. In the afternoon a reception was held at the home of the President.

On June 19 the members visited the State Sanitarium for Bone Tuberculosis at Lakeville, the orthopaedic work of which is under the direction of Dr. Z. B. Adams. The buildings were inspected, and in the afternoon a scientific session was held at which the treatment of tuberculosis of bones and joints was considered. The program was as follows:

Symposium on Treatment of Tuberculosis of the Hip, Knee, Ankle, and Tarsus:

The Non-operative Treatment of Tuberculous Joints of the Lower Extremity.
Dr. Horace Lo Grasso, Perrysburg, N.Y. (By invitation).

The Operative Treatment of Tuberculous Joints of the Lower Extremity.
Dr. Russell Hibbs, New York, N. Y.

Discussion by Dr. E. W. Ryerson, Chicago, Ill.
Dr. Frank C. Kidner, Detroit, Mich.
Dr. John Wilson, Los Angeles, Calif.
Dr. C. F. Eikenbary, Seattle, Wash.

The members then proceeded by auto to the Chatham Bars Inn, in Chatham, where scientific sessions were held the two following days—June 20 and 21. The following program was presented:

JUNE 20

The Treatment of Fractures:

Dr. Lorenz Böhler, Vienna, Austria (By invitation).
Discussion by Dr. E. S. Geist, Minneapolis, Minn.
Dr. Charles S. Scudder, Boston, Mass.

Symposium on Bone Physiology:

The Reaction of Bone to Defects in the Articular Cartilage.
Dr. J. Albert Key, St. Louis, Mo.

Bone Repair in the Presence of Aseptic Necrosis Resulting from Fractures, Transplantations, and Circulatory Disturbances.
Dr. D. B. Phemister, Chicago, Ill.

Blood Serum Calcium in Relation to the Healing of Fractures.
Dr. Kellogg Speed, Chicago, Ill.

Influence of Alterations of the Circulation upon the Growth of Bone.
Dr. J. J. Morton and Dr. Herman E. Pearse, Jr., Rochester, N. Y. (By invitation).
Discussion by Dr. Joseph Aub, Boston, Mass.
Dr. Robert B. Osgood, Boston, Mass.
Dr. Robert D. Schrock, Omaha, Nebr.
Dr. R. I. Harris, Toronto, Canada.

JUNE 21

President's Address.
Dr. Z. B. Adams, Boston, Mass.
An Operation for the Correction of Paralytic Genu Recurvatum.
Dr. A. Bruce Gill, Philadelphia, Pa.
Discussion by Dr. Oscar Miller, Gastonia, N. C.
Dr. Leo Mayer, New York, N. Y.
Fixed Paralytic Obliquity of the Pelvis.
Dr. Leo Mayer, New York, N. Y.
Discussion by Dr. Arthur T. Legg, Boston, Mass.
Neurotrophic Lesions of Bone in Leprosy.
Major Norman T. Kirk, U.S.M.C., Washington, D. C.
Discussion by Dr. J. Warren White, Greenville, S. C.
The Use of the Maggot in the Treatment of Osteomyelitis.
Dr. William S. Baer, Baltimore, Md.
Spondylolisthesis.
Dr. Henry W. Meyerding, Rochester, Minn.
Discussion by Dr. S. Kleinberg, New York, N. Y.
Dr. Z. B. Adams, Boston, Mass.
Treatment of Fractures of the Neck of the Femur by Open Reduction and Fixation with a New Type of Nail.
Dr. M. N. Smith-Petersen, Boston, Mass.
Discussion by Dr. George E. Bennett, Baltimore, Md.

The guest of the Meeting was Prof. Böhler, of Vienna, who presented to the Association his method of treating fractures, which was explained in detail and illustrated by many lantern slides and reels, and received with great satisfaction by the members and guests of the Association. It was felt that Dr. Böhler had presented material illustrating principles of treatment and results which add a great deal to the general fund of knowledge in regard to the treatment of fractures.

Six new members of the Association were elected, as follows:

Dr. W. B. Carrell, Dallas, Texas.
Dr. A. G. Davis, Erie, Pa.
Dr. G. W. Leadbetter, Washington, D. C.
Dr. H. C. Schumm, Milwaukee, Wis.
Dr. E. L. Scott, Birmingham, Ala.
Dr. C. E. Sevier, Denver, Colo.

Prof. Ernest W. Hey Groves, of Bristol, England, was made an Honorary Member of the Association.

The following officers were elected for the ensuing year:

President: Dr. Willis C. Campbell, Memphis, Tenn.
President-Elect: Dr. W. E. Gallie, Toronto, Canada.
Vice President: Dr. H. Winnett Orr, Lincoln, Nebr.
Treasurer: Dr. John L. Porter, Chicago, Ill.
Secretary, Dr. DeForest P. Willard, Philadelphia, Pa.
Executive Committee: Dr. Z. B. Adams, Boston, Mass.
Membership Committee: Dr. J. Archer O'Reilly, St. Louis, Mo.
Program Committee: Dr. Henry W. Meyerding, Rochester, Minn.

Delegates to the American College of Surgeons: Dr. John L. Porter, Dr. J. P. Lord, and Dr. Frederick J. Gaenslen.

REPORT OF A COMMISSION APPOINTED BY THE AMERICAN ORTHOPAEDIC ASSOCIATION TO STUDY THE END RESULTS OF INTRACAPSULAR FRACTURES OF THE NECK OF THE FEMUR

At the 1928 Meeting of the American Orthopaedic Association the incoming president, Dr. Fred H. Albee, was directed to appoint a commission to study the true end results of unimpacted fractures of the neck of the femur within the capsule in persons over sixty years of age.

At the 1929 Meeting of the Association, the first report was presented and accepted. The Commission was reappointed for another year, in order that it might make a comparative study of the true end results of the same type of fracture in persons under sixty years of age treated by various closed methods and in persons of any age treated by methods of open surgical attack. No case was to be considered a true end result in either the first or second report unless at least one year had elapsed between the inception of treatment and the date on which the end result was recorded. The Commission's second report was presented and accepted at the 1930 Meeting of the Association.

Method of study.—A personal explanatory letter and a brief questionnaire were sent the first year to the chiefs of about twenty large and well conducted fracture clinics in different parts of the United States, requesting the information desired. A similar letter and questionnaire were sent to many of the same clinics and certain other clinics the second year.

In 1928-1929 only seven clinics and in 1929-1930 only nine clinics submitted reports in sufficient detail to make them available for study. In many large clinics no true end results could be furnished. The clinics from which the Commission has been able to obtain figures which they consider reliable are the following, alphabetically arranged by cities: Boston, Mass. (Massachusetts General Hospital Fracture Clinic and private practice, A. W. Reggio, M. N. Smith-Petersen and P. D. Wilson); Des Moines, Ia. (hospital and private practice, C. E. and V. A. Ruth); Lincoln, Neb. (hospital and private practice, H. W. Orr and J. E. Thomson); Los Angeles, Cal. (Los Angeles General Hospital, J. C. Wilson and F. M. McKeever); Memphis, Tenn. (hospital and private practice, W. C. Campbell, J. S. Speed and J. I. Mitchell); Minneapolis, Minn. (hospital and private practice, E. S. Geist and M. O. Henry); New York, N. Y. (New York Hospital, J. M. Hitzrot; Post-Graduate Hospital and private practice, F. H. Albee; Presbyterian Hospital, Wm. Darrach and C. R. Murray; private practice, Armitage Whitman); Rochester, Minn. (Mayo Clinic, M. S. Henderson); Tacoma, Wash. (hospital and private practice, E. A. Rich).

The Commission regrets that true end-result reports have not been made available for study from two large fracture clinics in which special and widely employed methods of treatment have originated.

We realize that studies conducted in this manner must be less conclusive than if it had been feasible for the Commission to inspect personally the cases under discussion and to study the roentgenograms of the end results. The difficulty of assembling at one time and place these patients, so many of whom were elderly and whose accidents had occurred at varying times, made such personal inspection impractical. No case was accepted as a case of proved bony union unless a roentgenogram was reported to show true bony union at least a year after the treatment had been instituted. The salient points in these two reports are herewith submitted.

The material upon which the first report, presented in 1929, was based comprised a review of 331 fractures, of which number the results of 201 were suitable for study. The material upon which the second report, presented in 1930, was based comprised a review of 419 fractures, of which number 365 were suitable for study. Of this number

262 had been treated by closed methods and 103 by open surgical attack. The first report included only fractures occurring in persons over sixty years of age treated almost entirely by closed methods. The second report included, with a few exceptions in the series of Reggio and Ruth, some of whose cases were over sixty years of age, only fractures treated by closed methods occurring in patients under sixty years of age and fractures occurring in patients of any age treated by methods of open surgical attack. End-result figures of any method may be expected to be more favorable if only cases under sixty years of age are included. This perhaps makes the showing of the results from operative methods the more impressive, although the Commission realizes that only two considerable series of operative end results were available for study.

One of these two methods of open surgical attack is the method of Albee (See Surgery, Gynecology and Obstetrics, XLIX, 810, Dec. 1929), who in all cases in which union has not been secured by closed methods in three months believes that a vascular conducting medium, extending from the great trochanter to the proximal portion of the anaemic neck and head, should be supplied by means of an accurately fitting fresh autogenous tibial bone-graft peg. Most of the cases included in this report were cases of intracapsular fractures which had failed to unite by other methods. While the inclusion of these cases may be open to the criticism that they represent more or less selected cases, they would probably comprise a more, rather than a less difficult class of cases for obtaining proved bony union.

The other operative method is the method of Smith-Petersen (Report to be published in *The Journal of Bone and Joint Surgery*), who after open accurate reduction of the fragments employs a specially devised three-flange nail driven from the trochanter across the line of fracture well into the proximal portion of the neck and head fragment. The proximal and distal fragments are firmly impacted while under direct observation and both the position and fixation of the fragments are assured before closure. Most of the reviewed cases treated by this method were cases of fresh intracapsular fracture not previously treated by any other method.

Summary of 1929 Report

I. Incidence of intracapsular fractures of the neck of the femur in persons over sixty years of age.

(a) Occurrence incidence:—The Commission is unable to furnish accurate percentage figures of these serious fractures, but in one large fracture service these fractures comprised about five per cent. of all fractures admitted to the wards of the hospital.

(b) Age incidence:—From one large fracture service, in a period of three years, about seventy-five per cent. of all intracapsular fractures admitted to the wards had occurred in persons over sixty years of age.

(c) Sex incidence:—Of 331 fractures from seven clinics, about twenty-five per cent. were in males and seventy-five per cent. in females.

II. Mortality.

The mortality percentage in this elderly series from seven clinics was twenty-eight and six-tenths.

III. Proved bony union one year or more after treatment was instituted.

The percentage of proved bony union in the 201 cases available for study was thirty and four-tenths.

IV. Entirely satisfactory end results but not proved bony union one year or more after treatment was instituted.

The percentage of satisfactory end results (including in this category the cases of proved bony union as under III) was fifty and four-tenths.

V. Non-union or death one year or more after treatment was instituted, death being presumably attributable to the immediate or remote effect of the fracture.

The percentage of non-union or death was forty-nine and six-tenths.

VI. Methods of treatment.

The method of closed treatment employed most generally in the seven clinics whose reports were suitable for study was the Whitman treatment of reduction and adequate fixation in abduction and internal rotation in plaster. In reviewing a small number of case reports in which other closed methods of treatment had been employed, the Commission gained the impression that the percentage of satisfactory end results was considerably higher when the Whitman method was efficiently employed than the percentage obtained by any other of the methods reviewed at that time by the Commission.

The Commission comments as follows on its findings in this first report:

1. These serious fractures in elderly people are of sufficiently common occurrence to warrant special attention from surgeons treating fractures.

2. About three times as many of these fractures are sustained by persons over sixty years of age as by persons under sixty years of age, and in this series there were three times as many women as men.

3. The mortality in this series was high, twenty-eight and six-tenths per cent.

4. The percentage of proved bony union at the end of one year or more is low in our series, only thirty and four-tenths.

5. The Commission feels that the end results available for study in this series are not as satisfactory as they should be and that earnest attempts should be made to perfect our methods of treatment.

SUMMARY OF 1930 REPORT

I. Sex incidence.

In this second series of cases, in which are included fractures occurring in persons under sixty years of age, there is a higher percentage of males than in the first series comprising only fractures occurring in persons over sixty years of age, forty-four per cent. as compared to twenty-five per cent.

II. Mortality.

The mortality rate is lower in this second series of younger cases treated by closed methods, nine and two-tenths per cent., as compared with twenty-eight and six-tenths per cent.

The mortality rate of cases of all ages treated by methods of open surgical attack was two and seven-tenths per cent.

III. Proved bony union one year or more after treatment was instituted.

In the first series comprising only patients over sixty years of age treated by closed methods, the percentage of proved bony union was thirty and four-tenths. In this second series, comprising mainly cases under sixty years of age treated by closed methods, the percentage of proved bony union was fifty-one and nine-tenths.

The percentage of proved bony union in cases of all ages treated by methods of open surgical attack was eighty-six and four-tenths.

IV. Entirely satisfactory end results but not proved bony union one year or more after treatment was instituted.

The percentage of satisfactory end results (including in this category the cases of proved bony union as under III) in the first series of cases over sixty years of age treated by closed methods was fifty and four-tenths. In this second series, comprising mainly cases under sixty years of age treated by closed methods, the percentage was fifty-seven and seven-tenths.

The percentage of satisfactory end results in cases of all ages treated by methods of open surgical attack was eighty-one and five-tenths.

V. Non-union or death one year or more after treatment was instituted, death being presumably attributable to the immediate or remote effect of the fracture.

The percentage of non-union or death in the first series over sixty years of age treated by closed methods was forty-nine and six-tenths. In the second series, comprising mainly cases under sixty years of age treated by closed methods, the percentage was forty-five and eight-tenths.

The percentage of non-union or death in cases of all ages treated by methods of open surgical attack was fourteen and one-tenth.

VI. Methods of closed treatment.

(a) The method of closed treatment employed in 210 cases of this second series from eight clinics was the Whitman method, either in detail or in principle. Of these, 113, or fifty-three and eight-tenths per cent., resulted in proved bony union at the end of one year or more after the treatment had been instituted.

(b) The Ruth method of closed treatment (See Journal of American Medical Association, XCIV, 169, Jan. 18, 1930), was employed in this second series in twenty-three cases from one clinic. Of these, fifteen or sixty-five and two-tenths per cent. resulted in proved bony union at the end of one year or more after treatment had been instituted.

(c) The Orr-Thomson method of closed treatment (See Surgery, Gynecology and Obstetrics, XLVII, 101, July 1928) was employed in this second series in twelve cases from one clinic. Of these, eight, or sixty-six and six-tenths per cent., resulted in proved bony union at the end of one year or more after treatment had been instituted.

(d) The Albee method of open surgical attack (See Surgery, Gynecology and Obstetrics, XLIX, 810, Dec. 1929) was employed in the second series in thirty-nine cases from one clinic. Of these, thirty-eight, or ninety-seven and four-tenths per cent., resulted in proved bony union at the end of one year or more after treatment had been instituted.

(e) The Smith-Petersen method of open surgical attack (open reduction and special flange nail, unpublished) was employed in this second series in thirty-one cases from two clinics. Of these, twenty-six, or eighty-three and eight-tenths per cent., resulted in proved bony union at the end of one year or more after treatment had been instituted.

The Commission comments as follows on its findings in this second report:

1. The percentages of proved bony union and satisfactory end results in unimpacted intracapsular fractures of the neck of the femur in patients under sixty years of age and treated by closed methods are higher than in patients over sixty years of age, and the percentage of non-union or death is lower. The mortality rate of this second younger series is markedly lower.

2. The percentage of proved bony union one year or more after the institution of treatment is higher in the cases of all ages treated by open surgical attack than in the cases treated by closed methods. Only four considerable series of end results of open surgical attack comprising two methods were available to the Commission for study. In the series treated by the bone-peg or Albee method, most of the cases represented ununited fractures. While bony union might be expected to be more difficult to obtain in such cases than in cases of fresh fracture, the element of selection of cases enters and the Commission can justly compare only cases of fresh fracture treated by the special flange nail, or Smith-Petersen method of open surgical attack, with cases of fresh fracture treated by closed methods. The number of end results of this latter method of open surgical attack, available to the Commission, is too small and the results have been obtained by too small a group of surgeons to make it justifiable for the Commission to draw any conclusion as to the comparative success of the closed and open methods of treatment of unimpacted intracapsular fractures of the neck of the femur.

The Commission takes this opportunity of expressing its gratitude to the various surgeons who have made these reports possible, often at the expense of much labor.

Willis C. Campbell, M.D., Memphis, Tenn.
H. Winnett Orr, M.D., Lincoln, Neb.
Robert B. Osgood, M.D. (chairman), Boston, Mass.

Volume LXVII of **Acta Chirurgica Scandinavica** was published as one volume and dedicated on his sixtieth birthday to Prof. Patrik Haglund by his pupils and colleagues. The frontispiece is a fine picture of Prof. Haglund. There are 978 pages comprising sixty varied orthopaedic articles contributed by outstanding men of fourteen countries. Abstracts of some of these articles will appear in the January number of *The Journal*.

At the **Hospital for Joint Diseases** in New York City, has recently been established a new lectureship for the purpose of increasing interest in orthopaedic surgery and extending the knowledge of recent advances in this specialty. This is to be known as "The Sir Robert Jones Lecture". The plan is to invite each year some eminent orthopaedic surgeon to deliver one or two lectures at the hospital, to hold special clinics, to operate on difficult orthopaedic conditions, and to demonstrate new operative methods to the medical profession. The first lecture under this new lectureship will be given by Dr. Willis C. Campbell of Memphis, Tennessee, on Saturday evening, October 18, at the hospital. Dr. Campbell's subject will be "The Physiology of Arthroplasty".

The Sixth Congress of the **Czecho-Slovakian Orthopaedic Society** was held on June 28 and 29, 1930, in Zlín and in Luhačovice in South Moravia. There were present as guests a large number of delegates from foreign countries, also representatives of the shoe industry to consider the problem of shoes with the medical profession. The main subject of the Congress was "The Foot and the Shoe".

Dr. M. Jaroš, of Prague, spoke on "The Construction of the Foot from the Anatomical-physiological Point of View". The human foot has a threefold function,—static, kinetic, and adaptive, and due to its unique construction is capable of performing all these functions at the same time. Besides, the foot plays an important part in the exchange of warmth and perspiration. The shoe of today not only protects the foot, but also aids in its functions, nevertheless it weakens the muscles, and therefore an active reeducation of the muscles is necessary. The line of Meyer can only exceptionally be regarded in the construction of shoes. As a rule, the sole should be made on the line passing through the middle of the heel to the second toe; and, in the main, the sole should not be smaller than the impression. The middle part of the sole must be firm and fit the long arch. The heel of the foot should rest horizontally, not obliquely, on the heel of the shoe which should be two to four centimeters in height. The back of the shoe should be firm and the front portion sufficiently large and high to allow the toes sufficient space. The material of construction is important, leather being preferable. Rubber shoes and also the rubber top-shoes are harmful if worn during the day's work. The ideal hygienic shoes can be made, but must be handwork, suited to each individual. Such products are prohibitive in price; then too these are dependent on shoe lasts, often factory-made, and on the individual ability of each shoemaker. Therefore it is admitted that for the normal foot a hygienically made factory shoe may be suitable and may be less harmful than a badly hand-made shoe.

Dr. Račanský of Zlín spoke on "The History of Footwear and the Interest Which Physicians Have Taken in This Industry". The speaker outlined the history of shoe production from the earliest time to the present day, and followed the important stages in the history of shoe manufacture. The heel was introduced about the year 1600. In the second part of the nineteenth century the line of Meyer began to predominate and cucumber-shaped shoes were made with a valgus position. The line of Meyer, however, proved to be a mistake and the axis of the foot was rearranged according to new anatomical knowledge. Siebert and Weinert constructed the varus type of lasts, still used today. The hard pavements of the towns required a heel four to five centimeters high. Shoe production, which formerly was a handcraft, is today the work of factories and in many, as in the factory of Mr. Baťa, a special kind of hygienic shoes are made.

Dr. Charles Lasserre of Bordeaux spoke on "The First Cuneiform Bone, its Variation and its Function in the Morphology and in the Statics of the Foot". In adolescents and adults the speaker has observed an elevation on the back of the foot in the vicinity

of the first cuneiform bone (*le cou du pied fort*), which can be best demonstrated by x-ray when the foot is three-quarters flexed or on the lateral aspect. The speaker has observed this projection in patients who show other epiphyseal enlargement, and considers it allied to Schlatter's disease. In many cases, he is convinced that it is an incomplete "doubling" of the first cuneiform bone; according to Pfitzner, one center of ossification develops in the dorsal and the other in the plantar part of the foot. It may also be inflammation. The treatment is prophylactic, occasionally operative.

Dr. Lasserre also discussed the occurrence of metatarsus varus congenitus and other defects of the anterior foot. (Dr. Lasserre's discussion of this condition has already been presented in *The Journal*, XII, 695, July 1930.)

Dr. A. Srovnalík of Brno, spoke on "Types of Walk and their Significance for the Foot", emphasizing the value of employing means to prevent foot defects and advocating the elastic gait with only slight eversion. It is regrettable that insufficient care is given as yet to the teaching of such elastic and proper gait especially in schools and gymnasiums; and in the army this matter, as yet, is not given such attention as it deserves.

Dr. Malo Šarčevič of Veliká Gorica had as his subject: "Cases of Operation in Pedes Plano Valgi Contracti". In eight operated cases with bilateral involvement the tendon of the tibialis anterior was shortened and attached to the cut tendon of the peroneus brevis in such a manner that between the two cut ends of the brevis tendon there was a space of about six centimeters. The foot was kept in plaster for four weeks and walking was resumed, with plates, in six to eight weeks. The results were good in all cases, while after a mere redressment in narcosis and in plaster bandage relapse often occurred. In two cases (four operations) the peroneus tendon was frozen; the function returned after five or six months, but this operation is less certain and is not recommended.

Dr. Robert Nebeský from Plzeň spoke on "Prophylaxis of Flat-foot". Flat-foot is caused, in the first place, by static overloading, especially with everted gait and with hyperextended knees; and second, is consequent to various illnesses,—*e.g.* trauma, rickets, tuberculosis, rheumatic disease, and also general physical weakness. The prevention of flat-foot must begin at an early age, between the first and second years; and especially the lateral deviation of the heel in children with rickets must not be overlooked. Often flat-foot appears after the seventh year of age and in the period of puberty. It is necessary to introduce regular medical inspection of children's feet. At present, school physicians, especially trained in orthopaedic surgery, should give special attention to the feet of children in the course of their regular inspections, and should correct the wrong way of standing and eliminate the harmful types of shoes. The barefoot gait is preventive. Shoes should be made on varus lasts, with a broad heel, three centimeters in height and raised on the inner side.

Dr. Nebeský also said, in giving his "Estimation of Orthopaedic Plates" that an orthopaedic plate can fulfil its purpose only if it is made according to the individual indications. It is first essential to determine that the defect in question is really a flat-foot.

Dr. J. Mourek of Bohumín spoke on "Hallux Valgus and Its Relation to Shoes", and on the "Results of the Mayo Operation". It is a proof of progress that today the orthopaedic surgeon is a constructor of shoes, as seen in the factory of Mr. Baťa at Zlín. Unfortunately this is as yet exceptional, but as a result of the discussion at this session the attention of the Czecho-Slovakian orthopaedic surgeons should be urgently called to the injury that is caused by wrong shoes. The speaker recommended that the constructors of shoes should respect not only the necessary interests of fashion, but also the advice of an orthopaedic surgeon.

Dr. J. Čípek of Prague described "The Result of the Operation of Miller in Pes Planovalgus". Schulz modified the operation of Miller in the following way: he does not lengthen the Achilles tendon and does not make the resection of the neck of the astragalus, even in severe cases, but cuts a wider hollow, when resecting the joint between the first cuneiform and navicular bone and between the first cuneiform and metatarsal bone. Massage and exercise are begun in a fortnight after the operation. Since 1927 fifteen patients have been operated upon in Jedlicka's Institute. In eleven

cases the operation was bilateral. The results of the operations were good, there was a good reconstruction of the arch; it is necessary, however, to continue the treatment after operation by means of baths, exercise, and supports, made from casts of the foot.

Emphasis was made of the need of special attention to the geometrical form and axis of the heel, the avoidance of too great lengthening of the back lever of the foot, the attention to the position of the center of gravity of the foot, and to the angle of the mediotarsal joint, as well as to the preventive treatment of foot disorders, especially as regards shoeing, by Dr. Miroslav Jaroš, Dr. Ervin Neufeld, Dr. Jaroslav Vavrda, Dr. J. Koudelka, Dr. Otaker Schulz, Dr. Ing. E. Bělavský, Prof. Stanislav Kostlivý, Mr. Jankú.

In the discussion which followed the presentation of these papers, Dr. Frejka expressed his satisfaction that in all the reports the preventive function of the hygienically faultless shoe was emphasized, and he is convinced that in this way,—namely by the effort to protect the people against the diseases and defects in question, the Czecho-Slovakian Orthopaedic Society will obtain in a short time full approval and success.

To the report of Dr. Mourek he would add that he has also used the operation of Mayo with good results, but that he now employs, for the most part, the modified oblique osteotomy of Chlumský. The osteotomy of Chlumský has one disadvantage,—namely, that the end of the proximal fragment is sometimes too short and afterwards may hinder movement in the metatarsophalangeal joint. Therefore the speaker changed the operation in such a way that he added to the oblique osteotomy of Chlumský a parallel resection of the diaphysis of the bone (about one to two centimeters in size). The results, both immediate and permanent, are ideal and the advantage of this operation, when compared with the operation of Mayo, lies in the fact that the metatarsophalangeal joint is preserved.

Dr. Račanský considers the operation of Mayo unphysiological and he performs the cuneiform osteotomy of Reverdin and adds to it the operation of Hohmann with good results.

Dr. Josef Popper reported late results of the mediolateral osteotomy of Chlumský; in thirty cases, the results were functionally and cosmetically good and permanent.

On June 29, after an inspection of the baths of Luhačovice, Docent Schulz, the President of the Society, reopened the program of the Congress by a eulogy of the late President of the Czecho-Slovakian Orthopaedic Society, Prof. Zahradnický.

Prof. Ninger, the Dean of the Masaryk University of Brno, welcomed the Congress in the name of the medical faculty and announced the resolution passed by the university senate to organize in Brno a special orthopaedic clinical department to be placed temporarily in the old provincial infirmary during the building of a special orthopaedic hospital on Kraví Hora. This report was received with great satisfaction.

Then Dr. Glücksmann outlined the treatment at the baths at Luhačovice, which is applicable to cases of arthritis, gout, rheumatism, and tuberculosis. The cure consists partly of climatic influences, partly of rightly chosen food, and partly of the drinking of mineral waters.

Dr. Minář of Lublaň spoke on "Calcaneodynia, Its Pathogenesis and Cure". In children and young people the condition is an apophysitis of the os calcis, occurring after trauma, with rickets, with glandular disturbances, or by overstrain of the Achilles tendon. A characteristic feature is insufficient ossification. In adults there is an overproduction of bone in the form of spurs, seen after injury, or with osteo-arthritic, gonorrhoeal, luetic, and tuberculous diseases. The immediate cause is static and mechanical ("*maladie de trottoir*"). The treatment for children and young people is conservative only; rest, with plaster bandage is employed. In adults, operation is often advisable; it is necessary to remove the whole spur and at the same time the inflamed and sclerotic tissues in the vicinity. The speaker, however, has had less satisfactory results after these operations and he recommends conservative antiphlogistic treatment by rest, plaster bandage, and water.

Dr. Bedřich Frejka presented a paper on "Kyphosis Adolescentium". The speaker demonstrated three cases of kyphosis adolescentium, in which there was found beside the

typical changes on the vertebrae an oblong paravertebral abscess on both sides of the spine. An old and long existing cause of the condition in all three cases was tuberculosis, and the speaker considers that there may be some as yet undescribed forms of tuberculosis of the spine, which are at first accompanied only by a general and local weakness and produce no x-ray evidences in the spine. Only after several years there may appear on the vertebral bodies, with kyphosis, chronic ulcerous changes, which are quite visible on the skiagram and are interpreted as kyphosis adolescentium, or Scheuermann's disease. A contemporary paravertebral abscess proves the tuberculous character of the disease. The speaker recommended the study of the etiology of kyphosis adolescentium, investigation for evidence of previous tuberculosis, and to observe how often the anatomical changes of this kyphosis are combined with the paravertebral tuberculous abscess.

In the discussion, Dr. Zahradníček doubted whether in the cases that Frejka described, the abscess mentioned was really paravertebral. Dr. Bárta called attention to the relations between tuberculosis of the spine and Kümmell's disease. Dr. Frejka invited Dr. Zahradníček to Brno to examine the original films, for they leave no doubt that it is really a spondylitic abscess.

Dr. Frejka also spoke on "The Treatment of Spastic Paralysis of the Upper Extremities". In a case of ischaemic contracture the speaker obtained an excellent result by removing the proximal insertion of flexors on the hand and the fingers from the medial epicondyle, and by shifting the latter to a distal position. The result of this operation suggested the same procedure with the spastic paralysis of the upper extremities. But, with the active dorsal flexion of the hand, the operation is not completed, and after several weeks the flexor carpi radialis is transplanted under the skin to the dorsal side and is sewed into the periosteum and into the shortened tendon of the extensor carpi radialis, and the flexor carpi ulnaris is sewed to the extensor carpi ulnaris. He concludes that the operation is of use only in cases of real contracture and in these the motion of the hand is much increased. In cases without contracture the author transplants the tendon only.

Dr. Ervin Neufeld presented "A Contribution to the Question of the So Called Fibrous Osteitis". The speaker reported a case which after a blow on the knee had a suppuration of the joint and in the following years developed in different parts of the body so called spontaneous abscesses and fistulæ, about twenty in number, with resulting extreme deformities. After seven years he was taken to the orthopaedic clinic of Prof. Chlumský, and the x-ray showed changes resembling fibrous osteitis. The diagnosis lay between infectious and fibrous osteitis.

Dr. Lud. Billeš of Píšťany described "The Argental Test of the Serum in the Blood of Rheumatic Patients". In chronic polyarthritis the photosensitivity of the serum of the blood is considerably increased. The speaker described experiments made on a large scale for the purpose of examining the sensitivity of the serum with regard to different sources of light.

Dr. Billeš also spoke on "The Quantity of Cholesterin in the Serum of the Blood of Rheumatic Patients". The speaker observed in many patients with chronic polyarthritis a surplus of cholesterin. He noted that in secondary chronic polyarthritis the quantity of cholesterin was not increased, while in cases of primary chronic polyarthritis the increase of cholesterin is evident only when attacks are frequent. However, primary chronic arthritis with ankylosis and with contractures does not produce a change in the cholesterin of the blood serum.

Papers were also presented by Dr. L. Billeš of Píšťany, Prof. Bozidar Špišić of Zagreb, Dr. Dušan Polívka of Prague, and Dr. Otaker Schulz of Prague.

After the scientific session, the Congress elected Dr. St. Tobiášek and Dr. Lasserre of Bordeaux as honorary members. Dr. Bedřich Frejka of Brno was elected the new President of the Society; Dr. Jaroš and Dr. Vavrda, Secretaries; and Dr. Vlček, of Brno, the Treasurer of the Society. It was also voted that in addition to the Annual Congress, there should be held three meetings of the members every year in the three university towns of Czecho-Slovakia alternately.

Current Literature

L'Arthrite Chronique de la Hanche. By L. Duvernay, Paris, Masson et Cie, 1930, 40 francs.

In this monograph, by his treatment of the subject, the author shows the careful study and an extensive clinical experience and observation. It is of value for there are few affections in regard to which there is more confusion or more casual diagnoses made. The author has wisely not applied any special name to this group, but recognizes it as a form of rheumatic affection and uses this simple term of Chronic Arthritis of the Hip Joint.

In the clinical diagnosis, emphasis is made on the significance of four special symptoms, and although it must be recognized that no sign is purely pathogonomic, yet these are clearly suggestive in the diagnosis of this affection.

The author has divided the cases into four types,—(1) the simple; (2) the proliferating; (3) the ankylosing; (4) the deforming. These are accurately defined and are very fully illustrated by x-rays. The discussion of the etiology is particularly of value, and the many factors which may and do play a part are considered, but are not given undue prominence. The etiological factors are grouped as: (1) determining, (2) predisposing. Under the former are placed infections, toxic and traumatic, and particular importance is attached to the preexisting structural defects which may be the result of earlier trauma or disease. He acknowledges the fact, which clinicians must unfortunately recognize, that the treatment of this group is still discouraging. The advisability of the medical treatment is urged, and his advice in regard to the surgical procedures will serve as a valuable guide to those who have not had a large personal experience. The book is an unusually clear description of this group of pathological conditions of the hip joint which have sufficient characteristics to demand individual attention. The author states that this is the result of twenty years of study and he has presented a distinct contribution to the better understanding of this difficult subject.

The Action of Muscles; Including Muscle Rest and Muscle Re-education. By Sir Colin MacKenzie, M.D., F.R.C.S., F.R.S. (Edinburgh). Ed. 2. New York, Paul B. Hoeber, Inc., 1930.

When a scientist of note, who is at once an anatomist, a comparative anatomist, and an orthopaedic surgeon, writes on so technical a subject as is set forth in this book, the reader may rightly expect an output unusual and worth while. This handling of an all too meagerly studied subject is indeed noteworthy. Sir Colin has had and has availed himself of unusual opportunity to study the action of muscles in the human subject and in lower animals—especially in the marsupials and other forms found in Australia, where he lives. His frequent reference to variations from the human arrangements, found in muscle placements and in modified functions of these lower forms, is enlightening. In dealing with muscle rest, he defines it as the joint position of equilibrium between opposing muscles; and he insists on the importance of muscle rest in many pathological conditions.

All through the book, whether in the lengthened introductory chapter on Principles and the short interjected one on Anatomical Considerations in Joint Fixation, or in the thirteen chapters devoted to specific regions of the body, the author constantly refers to and describes abnormal muscle actions, particularly those found in poliomyelitis. Thus, his treatment of the subject of muscle reeducation in large measure refers to reeducation of the victim of infantile paralysis. MacKenzie's treatment of the subject of muscle reeducation parallels much that has been written by others, such as Lovett, but he goes

further in his use of gradual progression from simplest to more and more muscle-response efforts. Starting with the thesis that very few so called paralyzed muscles are truly down and out, he requires voluntary activity (though of the simplest form at first) rather than development of muscle activity by passive movements carried on by an outside force. Emphasizing his "zero position", or position of muscle rest, he insists that this is the position from which to initiate muscle reeducation. His prognosis for this kind of work is rather more optimistic than is the usual teaching in America, although much in line with the belief of the present reviewer.

Throughout the book one notes many original ideas. For instance, after restating the well known fact that the thymus gland is large in the infant, remains so up to the time of the development of the important muscular functions—due to the assumption of the erect posture and to walking—and then recedes; and theorizing on the belief that the thymus gland is necessary for this muscular development; the author hints that the administration of thymus gland might be beneficial in the early convalescent stage of poliomyelitis. Again, although his subject is not the surgery of paralysis, he frequently refers to tenotomies and tendon transplantations. But in line with his subject is his statement that rapid growth and development of a supposedly paralyzed muscle has followed the operative "removal" of the tightened sheath of the disused muscle, which tightening had "prevented" such growth and development. The present reviewer has not encountered this procedure.

Some of Sir Colin's sentences are long, involved, and difficult to follow; yet the reasoning of the book is logical. In the general discussion of muscle balance, he does not sufficiently weigh the effect of the force of gravity in many habitual positions. The illustrations are well chosen. There is a full index.

This book should be of value to physicians in general, but especially to the anatomist, to the neurologist, and to the orthopaedic surgeon. It might well be read by the student of physical training. The biologist would find the many references to muscle action in the animal kingdom interesting. The subject here treated should be part of the medical school course.

La Rachianesthésie: Sa Valeur et sa Place Actuelle dans la Pratique. By Prof. Émile Forgue and Prof. Antoine Basset, Paris, Masson et Cie, 1930.

In a 200-page monograph Émile Forgue, Clinical Professor of Surgery at Montpellier, and Prof. Antoine Basset of the medical faculty of the University of Paris, have supplied the literature with a most valuable treatise on this subject, covering its every aspect in a most fair and highly scientific manner. Faced by the facts in this review, it would seem impossible to deny that spinal anaesthesia has a sound and legitimate place in the practice of surgery; yet the possible dangers and complications, the definite indications and contra-indications, with the technical and physiological considerations on which these matters are based, are so clearly developed that even those experienced in the practice of this method could probably profit by the study of the authors' work, and to the novice it seems invaluable. From the angle of his own interest in this subject, the reviewer feels much indebted to Prof. Forgue and Prof. Basset.

The monograph embodies sections devoted to the history of the subject; the physiology; the clinical application with technique illustrated; complications and failures, with explanations and methods of handling; and embraces extensive statistical reviews of many European reports which are of particular value, the series of reporting surgeons ranging from one to twenty-five thousand cases. It possibly is to be regretted that no reference is made to some of the series reported by American authors, in which even larger numbers of cases have been reviewed.

In fact it was surprising to find the authors with the impression that in this country the interest in and practice of spinal anaesthesia was rather limited. "*Aux États-Unis, l'analgesie spinale est peu en faveur.*" This impression has apparently been obtained from the contribution of Stanton (*Annals of Surgery*, LXXXVI, 273, Aug. 1927) which though based on a questionnaire of some six hundred odd surgeons, does not, the reviewer

submits, very adequately cover the experience with spinal anaesthesia in this country, or present a picture at all similar to that which would result from a review of the American contributions on this subject of the last five years. However, it is probably true from the European figures, that this method of anaesthesia is much more prevalent in Europe than in this country. Like local anaesthesia, it possibly is too demanding of time on the part of the operator to fit into many of our clinic schedules. It is interesting to note, however, on the historical side, the observation from the authors' study that the discovery of the possibility of regional anaesthetization by spinal injection was first made by an American neurologist, Leonard Corning of New York, in 1885.

A review of this work can do no more than sketch its general character, but some of the authors' conclusions are worth repeating here. In the first place the authors are personally very strongly of the opinion that it is not to be advised for work above the diaphragm, and not to be considered very reliable in the upper abdomen; but below the umbilicus it possibly is the ideal anaesthetic for major operations. A second important conclusion is the contra-indication in cases of marked hypotension from whatever causes; and the authors properly submit that to accept as positive indications the contra-indications to general anaesthesia would be unfairly condemning the method on the basis of results. The reviewer noted with considerable interest the attitude taken by the authors—which coincided with that of many other European observers—toward the mechanism of the drop in blood pressure consequent to the spinal anaesthetic itself, but which is at variance with the prevailing conception in this country, in that cardiac depression was looked upon as the cause, and specific stimulants like caffein and camphorated oil advised in prophylaxis and treatment; while here the phenomenon is looked upon as being a local vasoconstrictor paralysis with splanchnic pooling of blood, and quite consistently controlled by the vasoconstrictor drugs particularly when given intravenously. Probably very proper emphasis in another conclusion is placed upon the responsibility, in the matter of technique, for failures and complications, with the suggestive fact from statistical study that the method varies consistently in results with the degree of the surgeon's experience with it. The authors very definitely feel that the drug used should be novocain or its derivatives, in a pure uncombined state, and feel that with proper technique and proper selection the mortality should not be greater than with inhalation anaesthesia, and that under the same conditions there are many good operative risks that would not well support any other anaesthetic.

SURGICAL DIAGNOSIS (Volume III and Index Volume). By American authors. Edited by Evarts Ambrose Graham, M.D. Philadelphia, W. B. Saunders Company, 1930. $35.00 a set.

The Journal acknowledges the receipt of a third volume of Graham's Surgical Diagnosis, and the index of the three volumes in the form of a separate book. This volume does not contain subjects of orthopaedic interest, as did the two previous volumes, which treated of the affections of bones and joints, and which were reviewed in *The Journal* of April 1930, but the close alliance of many orthopaedic conditions with the nervous system makes the chapters on "Surgical Diseases of the Spinal Cord" by Adson, "Peripheral Nerves" by Lewis, and "A Discussion of the Uses of Surgery in Conditions Involving the Sympathetic Nervous System" by Ranson, of unusual value to the orthopaedic surgeon. The overlapping of these two departments in many conditions—such as the affections of the spinal cord and spinal column, the deformity of the locomotive apparatus associated with nerve diseases and injury, and the increasing interest in the influence of the sympathetic system—is well recognized, and emphasizes the need of close cooperation between all who are working in these two special departments of medicine and surgery.

Not the least important part of this excellent work is the Index Volume, which provides ready access to every subject discussed in the three previous volumes. It represents a large amount of very careful work and will increase the value of Surgical Diagnosis in no small degree.

CONGENITAL CLUB-FOOT (Talipes Equinovarus). By E. P. Brockman, M.Ch., F.R.C.S. Bristol, John Wright and Sons Ltd.; New York, Wm. Wood and Co., 1930. $4.00.

This short book of 110 pages represents the prize essay for the Robert Jones Gold Medal for 1928, presented by the British Orthopaedic Association. It comprises an historical review of the treatment of club-foot from the time of Hippocrates. The old literature is well covered, but there are fewer references to the significant literature of the last decade. He recognizes three types of club-feet: the ordinary type; a second type associated with other deformities of the foot, of which he reviews three cases; and a third type associated with congenital absence of some of the bones, of which he reviews one case. There are excellent chapters on "The Normal Anatomy of the Foot" and "Pathological Anatomy"; and he reaches the conclusion that "the alterations in position of the scaphoid and os calcis with regard to the astragalus are only those which occur in the normal foot when it is adducted, inverted, and plantarflexed—but they are exaggerated in degree",—this in relation to the common type of club-foot. In the second type he deals with the lack of muscle development, and in the third type absence or partial absence of the bones of the foot or abnormalities of development.

As to the etiology, the author holds that neither (1) the defect in the germ theory; (2) the arrest of development theory; (3) the spasmodic muscular theory; nor (4) the mechanical theory offers entirely satisfactory explanations of the etiology. He considers that the lesion is due to a "congenital subluxation of the head of the astragalus out of its socket, owing to a congenital atresia of the acetabulum", comparing it to congenital dislocation of the hip. He summarizes by saying, "Congenital club-foot is caused by a primary failure in development to their full state of all the tissues of the foot. This involves the bones, the ligaments, and the muscles." He admits, however, that we do not know what influences the ovum, or causes failure of development.

He believes treatment should begin within a week or ten days following birth,—as soon as the child has adapted itself to an independent existence. Manipulations by trained hands, carried out regularly and scientifically, will bring about an overcorrection of most of the common types of club-foot, if between manipulations the foot is retained in an adhesive plaster splint applied over pads of felt. He points out that manipulations must not be discontinued until there is full overcorrection and the muscles of the child are capable of retaining the foot in overcorrection. He believes that division of the tendo Achillis should be only a last resort and should never be undertaken as long as any inversion of the os calcis remains. He thinks that only rarely are divisions of any other tendons necessary,—sometimes the tibialis posticus muscles. A description is given of an operation on relapsed feet in young children which consists, in the main, of the division of the ligaments on the sole and inner aspect of the foot, but does not mention any division of the deltoid ligament which Ober considers to be so important. The author also reviews other operative procedures. There are many case reports with excellent results.

The book is worthy of careful reading by all orthopaedic surgeons and worthy also of the medal it has won.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Report on Fifth International Congress of Military Medicine and Pharmacy, London, England, May 1929. By Commander William Seaman Bainbridge, M.C.-F. Menasha, Wisconsin. The Collegiate Press, 1930.

United Fruit Company, Medical Department. Eighteenth Annual Report. Boston, 1930.

Bulletino e Atti della Reale Accademia Medica di Roma. Rome, Vol. LVI, Nos. 6, 7, June, July 1930.

Hospital for Joint Diseases of the City of New York. Twenty-third Annual Report, for the year 1929.

The Johns Hopkins University Circular, School of Hygiene and Public Health, Catalogue and Announcements for 1930-31. Baltimore, New Series No. 4, 1930.

Slovansk´ Sborník Ortopedický. Brno, Czecho-Slovakia, Vol. V, No. 3, 1930.

Norsk Magasin for Laegevidenskapen. Oslo, Vol. XCI, Nos. 8, 9, August and September 1930.

Journal de Médicine de Bordeaux et du Sud-Ouest. Bordeaux, Vol. CVII, No. 20, 1930.

Giornale Medico dell' Ospedale Civile di Venezia. Venice, Vol. IV, No. 2, April 1930.

Ortopedia e Traumatologia dell' Apparato Motore. Naples, Vol. II, No. 3, June 1930.

Proceedings of the Staff Meetings of the Mayo Clinic. Rochester, Minn., Vol. V, Nos. 30, 32, 33. July 30, August 13, and 20, 1930.

A Survey of the Medical Facilities of Shelby County, Indiana: 1929. By Allon Peebles, Ph.D., The Committee on the Costs of Medical Care, Washington, June 1930.

The Scope and Aim of the Committee on the Cost of Medical Care. Washington, June 1930.

Gazetta Medica Italo-Argentina. Naples, Vol. XII, No. 16.

Medicina del Trabajo e Higiene Industrial. Madrid, Vol. 1, No. 4, July 1930.

*Die Knochenbruchbehandlung mit Drahtzugen. By Rudolf Klapp and Werner Block. Berlin, Urban & Schwarzenberg, 1930.

*To be reviewed in a later issue of *The Journal*.

Beitrag zur Kenntnis der Tumoren in den langen Röhrenknochen, ihre Diagnose und Therapie (The Diagnosis and Treatment of Tumors of the Long Tubular Bones). Ivar Behring. *Acta Chir. Scandinavica*, LXVI, 197, 1930.

Two hundred and forty-four cases of histologically proved osteosarcomas (including twenty-seven giant-cell sarcomas) were collected from forty-eight Swedish hospitals. In one hundred and forty additional cases, data were inadequate in some respects. A detailed statistical study is presented from which the writer draws many conclusions, some of which are as follows:

(1) In osteosarcoma of the femur, tibia, and humerus, with periosteal origin or central origin with perforation of the periosteum, resection, even if extensive, offers little hope.

(2) In osteosarcoma of the fibula, resection is followed by relatively favorable late results.

(3) When disarticulation of the hip or thoracoscapular amputation must be resorted to, the operative mortality is high and the late results bad.

(4) The prognosis is less favorable with the peripheral than with the central type.

(5) Exploratory osteotomy makes the prognosis worse.

(6) The infiltration of the regional lymph glands with tumor cells renders the prognosis absolutely bad.—*W. P. Blount, M.D., Milwaukee, Wis.*

The Roentgen Diagnosis of Rickets. Ralph S. Bromer. *Am. J. Roentgenol.*, XXIII, 469, 1930.

This is an exhaustive paper dealing with the clinical manifestations of the disease, development of bones, pathology, etc.

The roentgenologic appearance of normal bone is described and then the rachitic changes are very carefully outlined.

Three stages are described; and the active and passive types differentiated in each stage.

The author states that early in the disease the diagnosis must be made by clinical signs.—*Edward S. Hatch, M.D., New Orleans, La.*

SOME OF THE DEFORMING BONE DISEASES OF ADOLESCENCE. A. L. Gray. *Am. J. Roentgenol.*, XXIII, 485, 1930.

The paper describes the diseases of Scheuermann, Calvé, Legg-Perthes, Osgood-Schlatter and Köhler. The illustrations are good and points in differential diagnosis are noted. The author quotes from replies to letters he received relative to the question of a disease of the acetabulum, primary, corresponding to Legg-Perthes' disease. Opinions differ,—seven have never seen such conditions independent of diseases of the femoral head; five believe that such a condition is found.—*Edward S. Hatch, M.D., New Orleans, La.*

A FASCIA-CHECK BAND FOR RELIEF OF PARALYTIC GENU RECURVATUM. P. C. Colonna. *Ann. Surg.*, XCI, 624, 1930.

The author suggests for consideration an operation, having used it in one case of paralytic genu recurvatum. A fascial strip one and one-half inches wide is taken from the outer lower portion of the leg and stripped up to the head of the fibula, then rolled inside out above the knee and pushed subperiosteally behind the femur and brought down and reattached to the internal and posterior aspect of the tibia. There was no recurrence after one year. Photograph shows patient standing on one leg.—*C. D. Lowendorf, M.D., Iowa City, Iowa.*

CYSTS OF THE LONG BONES OF THE HAND AND FOOT. Harry Platt. *British J. Surg.*, XVIII, 20, July 1930.

The bones involved in the order of frequency are the phalanges of the hands, the metacarpals, and more rarely, the metatarsals. The cysts originate in the metaphyses, develop insidiously, and are usually discovered after an injury.

Studies on twenty cysts are reported. Microscopic examination was made of the contents of thirteen. One group was classified as chondromata or myxochondromata, in which there is no lining to the cyst and which contains cancellous bone, granulation tissue, and white glistening material. The others were cases of osteitis fibrosa with a tough fibrous lining easily peeled out. Clinical and radiological examination as a rule cannot distinguish between the two.

Cysts in young people may heal spontaneously and no operative treatment is necessary unless they are actively expanding or perforated by fracture, in which case exploration is indicated. Operation consists in curetting the cyst and cauterizing its interior with pure carbolic acid. Bone grafts inserted into the cyst hasten healing.

THE APPROACH TO THE HIP JOINT: A CRITICAL REVIEW AND A SUGGESTED NEW ROUTE. R. P. Osborne. *British J. Surg.*, XVIII, 49, July 1930.

The various operations for opening the hip joint are described. All operations by the anterior route are easy, bloodless, and do little damage; but give very little room for a good exploration. However, they are satisfactory for drainage. In the antero-lateral group the Smith-Petersen approach is suggested as the best for all "quiet" work. It is bloody and shocking because of its extensiveness, but the exposure is excellent.

The lateral approach depends on a division of the trochanter. This may be a source of complications in healing. It is contra-indicated in all septic cases. In the posterior group the Kocher operation gives good exposure but because of the division of the trochanter cannot be used in septic cases. Langenbeck's approach is from an incision carried from the posterior superior spine to the postero-superior angle of the great trochanter. The fibers of the gluteus maximus are divided, the gluteus medius and the pyriformis retracted, and the joint opened. The exposure is limited and drainage is difficult because of the high position of the pyriformis.

The new operation is a combination of the Langenbeck and Kocher methods. The incision is made, with the limb adducted across the sound limb, from a point one and three-quarters inches below the posterior superior iliac spine to the postero-superior angle of the great trochanter and then down the posterior edge of the trochanter for two inches. The gluteus maximus is divided longitudinally and retracted. The leg is rotated inter-

nally and the tendons of the pyriformis and the gemellic mass are divided close to their insertions. The capsule is thus exposed and is incised.

The advantages of this operation are: "(1) Almost the whole of the posterior surface of the joint and the neck of the femur is exposed; (2) There is no interference with the great trochanter; (3) The displacement of the tissues is slight and easily reparable; (4) There is adequate provision for drainage". The operation is suggested for infected cases requiring a direct attack on the joint or head and neck of the femur with subsequent drainage.

THE SPLINTING OF CASES OF TUBERCULOSIS OF THE HIP. M. Forrester-Brown. *British J. Surg.*, XVIII, 54, July 1930.

The difficulties in diagnosis of tuberculosis of the hip, the clinical types, and the stages of the disease are discussed. The usual methods of fixation and splinting are considered for the active stages. The author describes an ambulatory splint for the quiescent stage. The usual Thomas walking caliper is attached to body bars and a corset, allowing not over one or two degrees of motion. The details of construction are given.

The advantages of the splint are: (1) It takes the weight off the joint. (2) It eliminates flexion and adduction movements from the hip. (3) It allows access to the skin or to any existing sinuses. (4) It allows removal of the whole apparatus at night or for part of the day. The only disadvantage lies in the difficulty in securing accurate fitting.

ON SOME ASPECTS OF THE PATHOLOGY OF HYPERTROPHIC CHARCOT'S JOINTS. E. J. S. King. *British J. Surg.*, XVIII, 113, July 1930.

"(1) Hypertrophic Charcot's disease is a grotesque form of osteo-arthritis, and the exaggeration of the processes concerned is due to the more frequent traumatisms which are permitted by the anaesthetic conditions of the bones and joints.

"(2) The processes involved are anaplasia of the connective tissue cells to a primitive type, under the action of some stimulus, with subsequent differentiation in various directions.

"(3) The phenomena may be of such an anaplastic order as microscopically to suggest neoplasia.

"(4) It is suggested that the stimulus is the products of dissolution of small pieces of necrotic bone."

FRACTURES OF THE SPINE. WITH AND WITHOUT OPERATION,—A STATISTICAL STUDY. R. W. Harbaugh and R. E. Haggard. *California and West. Med.*, XXXII, 325, 1930.

A statistical study of results in ninety-seven cases of fracture of the lower dorsal and lumbar spines was made by the authors (who are officially connected with the California Industrial Accident Commission). Twenty-two of these cases had been treated by fusion operation and their average disability rating was 50.16 per cent. Sixty-seven cases not operated on had an average rating of 45.3 per cent. The time elapsed before permanent rating in the operated cases was fifty and two tenths months; in the non-operated cases, twenty-nine months.

The method of fusion was that of Hibbs in seven, that of Albee in fourteen, and a combination of the two in one. The majority of cases were treated by leading orthopaedic surgeons of California. The final rating was based on the report of the attending surgeon and of all physicians who had examined the patients, as well as statements of the patients regarding ability to work. Incidentally, it is noted that most insurance carriers and most surgeons are in too great hurry to get their cases rated and closed.

For fair comparison, the operated and non-operated cases were selected as nearly as possible from the same degree of severity. Most of them were laboring men. The factors considered by the rating committee are: (1) ability to work; (2) range of motion in the spine; (3) pain; (4) necessity of wearing a back brace.

In the discussion of this paper Dr. Chappel stresses the point that the industrial cases are always more prolonged than "private" cases, the latter returning to work in three to twelve months, usually with no disability. He attributes this to the psychologic factor and to excessive immobilization in the industrial cases.—*William Arthur Clark, M.D., Pasadena, California.*

DISTACCHI EPIFISARI SPERIMENTALI E ALTERAZIONI RACHITIFORMI DA STRONZIO (Experimental Separation of the Epiphysis and Rachitic Bone Changes after Strontium). E. Benassi. *Chir. d. Org. di Movimento*, XIV, 397, 1930.

The author follows the investigation of Cagnetto and others who studied the effect of strontium administration upon bone growth. Strontium phosphate in rather high doses produces changes in the skeletal growth which macroscopically as well as histologically closely resemble those of human rickets.

The author availed himself of this effect of strontium intoxication upon bone growth in order to study the processes of repair which follow experimental epiphyseal separations under such conditions. He corroborates, above all, the findings of others that strontium phosphate produces in the animal typical rachitic changes. The separation of the epiphyses which was produced experimentally occurs within the cartilage zone, usually in the zone of proliferation, less frequently in the juxta-epiphyseal vascular layer. Treatment with strontium influences the healing process of the separated epiphyses, callus formation is irregular, the callus is exuberant. Histologically also the callus formation appears much more irregular and disordered than under normal conditions.—*A. Steindler, M.D., Iowa City, Iowa.*

L'INFLUENZA DELLE INFEZIONI SPERIMENTALI SULLE ALTERAZIONI OSSEE DA CARENZA (Influence of Experimental Infections on Bone Atrophy). L. Baj. *Chir. d. Org. di Movimento*, XIV, 477, 1930.

The author undertook to study the effect of experimental scurvy with a view of establishing the changes which scorbutic bone undergoes when infection is superimposed. The experiments were arranged as follows: first, a group of guinea-pigs under scorbutic diet, without treatment; second, guinea-pigs under scorbutic diet, exposed to staphylococcus injection; third control pig under normal diet exposed to staphylococcus injection; and fourth, guinea-pigs with scorbutic symptoms, exposed at a later date to staphylococcus injection.

The results obtained with infection with staphylococcus pyogenes albus in animals kept on a vitamin C free diet, lead the author to the following conclusions:

In experimental scorbutic avitaminosis, the most constant and most marked symptoms are those of the skeletal system. In animals under scorbutic diet, exposed to staphylococcus infection, in which suppurative symptoms have become manifest, the osseous manifestations are not marked. The infection does not, however, arrest the scorbutic symptoms when the latter are already established. The infection in scorbutic animals shows graver qualities than one in normally living animals.

The author draws the conclusion that the lack of the avitaminosis manifestations in infected animals may be attributed to the formation by the micro-organisms of an antiscorbutic substance.—*A. Steindler, M.D., Iowa City, Iowa.*

PSEUDO-RACHITISMO RENALE (Renal Pseudorickets). R. Zanoli. *Chir. d. Org. di Movimento*, XIV, 539, 1930.

Numerous observations are now at hand which substantiate the syndrome of renal rickets, such as kidney lesions, chronic interstitial nephritis, bone deformities, and retardation of growth. The condition is peculiar to infancy and adolescence.

Two cases are reported by the author from the Istituto Rizzoli. In the majority of the cases reported the renal lesion represents interstitial nephritis; albumen is present in traces.

Skeletal deformities are found in sixty-seven per cent. of the cases. The most common is genu valgum. The x-ray gives the picture of typical rachitic changes in the epiphyses. In one case reported by the author a stone was found in the bladder. The blood chemistry is not given.—*A. Steindler, M.D., Iowa City, Iowa.*

Über Diagnose und Behandlung der Patellarfrakturen. Carl Goebel. *Deutsche Med. Wchnsch .*, LVI, 465, 1930.

Discussing the common concepts of diagnosis and treatment of fractures of the patella, the author emphasizes several aspects of the problem. Every hemorrhage into the knee joint should be carefully examined for fracture of the patella. Too many are overlooked. The presence of clots on aspirations should arouse suspicions, as usually diffusions of blood do not clot. He emphasizes the importance of the lateral extensions of the patellar ligament as extensors of the leg on the thigh. Even in fractures of the patella, intact lateral extensions will permit motion of the leg invalidating this test in such cases. The other complications of knee injuries,—as semilunar and crucial ligament lesions—must not be forgotten.

The treatment of fractures in good position by immobilization in extension and aspiration of the joint after the fifth day is advocated only in cases where it is felt that the lateral extensions are uninjured. If there is diastasis of the bony fragments or tear of the lateral extensions, open operation should be resorted to without delay. The principles observed in repair are re-enunciated: removal of interposing material, cerclage (with gut as a rule), and repair of the lateral extensions and the anterior fascia over the patella. If the fascia is well approximated, the bone will hold without much trouble.

After repair, the leg is flexed and kept so (135 degrees) with a steel pin through the quadriceps tendon weighted with three to five kilograms, insuring rest to the patella. Early weight-bearing is not encouraged Massage and physiotherapy are useful but not indispensable adjuncts.

The author has not found it necessary to resort to periosteum bone-flap transplants from the tibia, enucleation of the patella, or other similar unusual methods.—*Joseph E. Milgram, M.D., Iowa City, Iowa.*

Traumatic Ulnar Neuritis. K. Paterson Brown. *Edinburgh Med. J.*, XXXVII, 97, 1930.

The author confines his discussion and report of cases to several groups. In the first, ulnar neuritis followed recent fractures. In fracture of the medial epicondyle, primary or secondary neuritis may occur. Given a primary contusion of the nerve, a neuritis may be set up by the use of forcible passive movements.

In the second group, late traumatic ulnar neuritis follows fracture of the lateral condyle of the humerus. Following the displacement of the fragment by the extensors of the forearm, cubitus valgus results and develops gradually. As a result of the longer course which the ulnar nerve must now take to reach the forearm, it is subjected to stretching. Ten, twenty, or even thirty years later, an intractable ulnar neuritis may develop.

Another cause of traumatic ulnar neuritis is repeated dislocation of the nerve from the postcondylar groove. Mobile nerves are frequent, but it is the rare cases in which complete anterior dislocation occurs in which operative intervention is necessary.

In all cases, satisfactory results were obtained by anterior transposition of the nerve, burying into the flexors of the forearm. The branches to the flexor carpi ulnaris and flexor profundus digitorum must be exposed and mobilized, and the nerve bared without twisting or tension. The intense pain is completely relieved within a few days. Muscular paresis is expected to slowly disappear.—*Joseph E. Milgram, M.D., Iowa City, Iowa.*

Fragility and Deficient Healing of Bone in Poliomyelitis. I. Harrison Tumpeer, and R. W. McNealy. *J. Am. Med. Assn.*, XCV, 19, July 5, 1930.

Experimentally, it has been proven that the bone atrophy occurring in a limb involved by poliomyelitis is not caused by the nerve injury, but purely by lack of use.

Likewise, it has been proven that in a bone subjected to extra stress and strain, such as is present in a case of Little's disease, where there is a constant strong pull by the muscles, the bone hypertrophies.

Case reports indicate that the nerve cell injury does not affect the formation of callus; but, on the other hand, the lack of use causes a union in a fracture of these bones to be of such a nature that it will not stand the slightest strain. It is for this reason that fractures in children who have had poliomyelitis frequently recur with the slightest injury.—*W. B. Carrell, M.D., Dallas, Texas.*

GONORRHOEAL SPURS A MISNOMER. William H. Von Lackum, and Emilio J. Palomeque. *J. Am. Med. Assn.*, XCV, 472, Aug. 16, 1930.

A review of 100 cases of a spur on the os calcis, made to determine the frequency of the gonococcus as a causative factor, is presented.

Calcaneal spurs are most common in persons whose occupations cause them to stand a great deal. Only forty-four per cent. of the cases gave a positive history of gonorrhoea. In five per cent. of cases the heel became painful in from three to four days after the onset of the gonorrhoea; in five per cent., after one to three months; in fifty-six per cent., fourteen years; and in three per cent., after thirty-four years. In a large number of these cases a definite source of infection, such as tonsils and teeth, was demonstrated.

Of the cases that did not give a history of gonorrhoea a large percentage showed infected tonsils or teeth. Therefore, the conclusion reached is the same as reported by a number of other observers,—that is, that probably foci of infection play a larger part in the production of os calcis spurs than does gonorrhoea.—*W. B. Carrell, M.D., Dallas, Texas.*

CERVICAL AND LUMBAR SYMPATHETIC RAMISECTOMY IN SPASTIC PARALYSIS. E. Hesse. *J. sovremennoi Chir.*, IV, 836, 1929.

After a detailed review of the literature on this subject, and on the basis of personal observations, the author comes to the conclusion that ramisectomy is a valuable procedure in spastic paralysis. He discusses critically the exaggerated praises as well as the total negation of the value of these operative procedures.

The author operated on eight patients; four lumbar and four cervical ramisectomies. Of the four lumbar cases, three gave very satisfactory results; the fourth case offered but little improvement. The cervical ramisections gave not as satisfactory results; only one case resulted in improvement. The lumbar ramisectomies are of greater value than the cervical ones.

Patients with the following affections were operated upon: spastic paralysis with cerebral injury; Parkinson's disease with symptoms of increased plastic muscle tonus; spinal cord injuries; spasticities after peripheral injuries with predominating vasomotor symptoms. The operation is contraindicated in cases with destruction of the cerebral cortex, in patients whose primary process has not yet subsided, and in individuals with marked mental disturbance.

The last word as to the value of this operative procedure cannot be spoken as yet. Many more clinical results will have to be reported.—*A. Gottlieb, M.D., Los Angeles, Calif.*

HOMOPLASTIC TRANSPLANTATION IN OSTEITIS FIBROSA CYSTICA. M. Ladygin. *J. sovremennoi Chir.*, IV, 904, 1929.

A case is reported of successful homoplastic transplantation of bone into the cavity of an operated fibrous cyst in the epiphysis of the tibia. The transplant was taken from the ribs of another patient and boiled one and one-half hours. X-rays demonstrate the formation of new bone in the cavity as a result of the irritation from the transplant, which aids in the ossification in the tibia. In four months the patient was cured.

This observation leads the author to conclude that osteitis fibrosa is a benign disease, and that the cavity which is formed after a thorough removal of all the elements of the disease can become filled by autoplastic or homoplastic transplantation.—*A. Gottlieb, M.D., Los Angeles, Calif.*

INTRA-ARTICULAR CHANGES AFTER THE REMOVAL OF THE SEMILUNAR CARTILAGES. G. Lukjanov and S. Pokrovski. *J. sovremennoi Chir.*, IV, 946, 1929.

Experiments on dogs of various ages disclosed that the removal of the menisci, partial or complete, has resulted in regeneration of the cartilages. These newly formed menisci develop from the synovial capsule as well as from the remnants of the cartilages. They differ from the normal ones neither in form nor in consistency; they are only less glossy and movable. The newly formed semilunar cartilages are functionally and statically of equal value with the ones removed. The experiments were performed on thirty-seven dogs, of which twelve died postoperatively.—*A. Gottlieb, M.D., Los Angeles, Calif.*

FRACTURE OF THE OS CALCIS. Otto J. Hermann. *New England J. Med.*, CCII, 705, 1930.

Fractures of the os calcis are more frequent than supposed and are usually due to a crushing force. The three main diagnostic points are:

1. A pushing up of the heel.
2. Broadening of the bone, chiefly outward.
3. Decrease of lateral mobility.

The method of treatment is one of pounding to break up the impaction; traction with tongues to pull heel down and give an arch; molding and fixation with thick felt pads beneath the malleoli. Frequent cast changes and physiotherapy complete the treatment. The foot is in equinus for ten days, and then at right angles and slightly in varus. After eight weeks pressure is brought to bear with turnbuckles fixed in a shoe. —*J. U. Kulowsky, M.D., Iowa City, Iowa.*

THE DIFFERENTIAL DIAGNOSIS OF LAME BACK. Leslie V. Rush. *New Orleans Med. and Surg. J.*, p. 847, June 1930.

In this paper the author places the etiologic factor of low back pain in one of the following classes:

1. Diseases of the abdominal viscera.
2. Tumors of the spinal cord and vertebrae.
3. Traumatic conditions.
4. Arthritis of the spine.
5. Diseases of the vertebrae.
6. Disturbances of posture and developmental anomalies.

He then goes into each one of these conditions very lightly. Nothing new is attempted.—*Edward S. Hatch, M.D., New Orleans, La.*

LES FORMES EXTRA-ARTICULAIRES DE LA MALADIE RHUMATISMALE (The Extra-articular Manifestations of Articular Rheumatism). H. Grenet. *Presse Méd.*, XXXVIII, 353, Mar. 12, 1930.

The author describes several general and local conditions, not of the locomotor system, as the background of articular manifestations. He describes infectious, systemic disease,—*i.e.*, typhoid form, and attenuated infectious forms of other types. Among the local conditions, cardial lesions and pleuropneumonic lesions are mentioned.

The so called esophageal form is a type first mentioned by Homolle in which pain in the esophagus precedes, accompanies, or follows articular symptoms. These are cases of more or less mild stenosis of the esophagus, such as one described by the author. In this case, the pallor, the existence of pericarditis, and the effect of salicilates indicated the existence of a rheumatic condition.

Another condition mentioned is pseudo-appendicitis with abdominal symptoms, pain, meteorism, and constipation. A case of this type is cited as well as a case of pseudo-cholecystitis.—*A. Steindler, M.D., Iowa City, Iowa.*

TRAITEMENT CHIRURGICAL DES DÉFORMATIONS RACHITIQUES DES MEMBRES INFÉRIEURS CHEZ L'ENFANT (Surgical Treatment of Rachitic Deformities of the Lower Extremities of the Infant). A. Delahaye. *Rev. d'Orthop.*, XVII, 48, 1930.

Among 898 rachitic children treated since 1923, 118 presented variations of the lower extremities which were sufficiently accentuated to demand surgical intervention. Among these cases there were sixty-five of unilateral or bilateral genu valgum, ten of unilateral or bilateral genu varum, twenty-seven of unilateral or bilateral anterior bent tibia, and sixteen were operated for complex and multiple femorotibial deformities, unilateral or bilateral.

Before operation of these various deformities is undertaken one must be sure that the rachitic process has subsided. This is shown by clinical examination, by x-ray examination, and the history. Age is of importance. At six or seven years the bones of a rachitic child are usually sufficiently recalcified, but there are numerous cases in which one must wait until nine or ten years. In the presence of bilateral deviation the author always operates on both sides at the same time, beginning with the side of the greater deformity. In the presence of multiple deviation or complex deformities of the same side the author usually begins with the most pronounced deformity and finishes with the least pronounced. Between the healing of one osteotomy and the undertaking of the next operation the author usually allows two months to pass, an interval of time which he found necessary for good consolidation. Supracondylar or linear transverse osteotomy was made with chisel, according to classical procedures, using an internal incision in the case of the genu valgum and an external incision in the case of the genu varum. Modeling osteotomies were done by convex and concave cuts, using Albee's saw which could be adapted to the purpose.

The principal steps of the surgical intervention are the following: skin incision at the level of the maximum curvature; stripping back and retraction of large osteoperiosteal flaps; subperiosteal osteotomy of the tibia with the Albee saw; osteoclasis of the fibula; modeling of the tibial extremities by means of special saw blades; coaptation of the so prepared surfaces; replacement of the periosteal flaps; suture of the skin; then application of the plaster-of-Paris cast. The author lays particular emphasis upon a careful application of the plaster-of-Paris cast which must be well adapted. During the time of setting, the limb is held in slight hypercorrection. The dorsum of the foot as well as the toes are left out so as to be better able to check up on mobility or circulation. The plaster cast is removed after an average time of forty-five days. Several of the cases operated had a positive Wassermann reaction, and an energetic treatment was instituted before the operative intervention and followed up for a considerable length of time afterward until the reactions became negative.—*A. Steindler, M.D., Iowa City, Iowa.*

CONGENITAL DISLOCATION OF THE HIP. Chas. H. Jaeger. *Surg., Gynec., Obstet.*, L, 757, 1930.

The author discusses the unsatisfactory end results in the treatment of congenital dislocation of the hip, and mentions the diagnostic signs before the child begins to walk. He advocates treatment by means of a splint which may be begun in early infancy. The splint consists of two circular bands of rustless steel which fix the chest and pelvis, two lateral bars to support the leg, and leather anklet attached to the bars to control rotation of the leg. The long outer bar is bent to hold the limb in forty-five degrees abduction, and with the limb in this position reduction is accomplished by applying pressure over the trochanter by means of an adjustable pad controlled by a wing screw. The pressure is applied gradually and reduction may be completed in four to six weeks.

The advantages claimed by the author for this method are that reduction is atraumatic, anaesthetics are unnecessary, treatment may be started earlier and completed sooner than by the ordinary methods. Two cases treated by this method are reported and good results were obtained in both.—*E. M. Cowart, M.D., Iowa City, Iowa.*

BONE CHANGES IN HYPERPARATHYROIDISM. Edward L. Compere. *Surg., Gynec., Obstet.*, L, 783, 1930.

The author reports the case of a woman, fifty-nine years old, who complained of pain in the legs and feet, bowing of the legs, and general weakness. Examination showed a palpable nodule in the lower pole of the right lobe of the thyroid gland. The serum calcium was elevated and the phosphorus was lower than normal. There was a negative calcium balance and roentgenograms showed an osteoporosis of the bones of the skull, spine, pelvis, and femora. An exploration of the thyroid gland revealed a small tumor of one parathyroid gland which was removed along with one normal parathyroid, and an adenoma of the thyroid. The calcium balance returned to normal limits and the patient improved clinically as shown by decrease of pain and increase in strength. —*E. M. Cowart, M.D., Iowa City, Iowa.*

THE USE OF IODIZED OIL (Lipiodol and Iodipin) IN THE DIAGNOSIS OF JOINT LESIONS. Philip H. Kreuscher and H. Kelikian. *Surg. Gynec., Obstet.*, L, 888, 1930.

The authors have injected iodized oil into hip and knee joints for diagnostic and therapeutic purposes. The conformation of the joint cavity, its capacity and communicating bursae, may be shown on the roentgenogram. Clinically, freedom of joint action and relief of pain have been reported in some cases of diseased joints.—*E. M. Cowart, M.D., Iowa City, Iowa.*

ÜBER OSTEOPATHIA DEFORMANS DES OS NAVICULARE PEDIS (CONCERNING DEFORMING OSTEOPATHY OF THE SCAPHOID BONE OF THE FOOT). B. Simons. *Ztschr. f. orthop. Chir.*, LII, 564, 1930.

The author describes a bilateral traumatic affection of the scaphoid discovered as an incidental finding in a male of forty years. For several years he had noted an increasing localized enlargement. Pain of varying severity was present. Only roentgenograms of the condition are appended, inasmuch as the opportunity for pathologic study did not present itself. The left scaphoid was divided into two roughly pyramidal portions, each sclerosed. The right scaphoid, while not definitely in two parts, appeared to be breaking up into two portions. The upper one contained rarefied areas; the lower was markedly sclerosed. The case is compared with Müller's and Köhler's cases.

The author is inclined to the opinion that the condition is not the result of any developmental anomaly but is the result of weight-bearing.—*J.E. Milgram, M.D., Iowa City, Iowa.*

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